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Low-Cost Application of the Model to Future-Year SIP Control and Alternative Fuel Strategies for Dallas-Fort Worth, Atlanta, Philadelphia, and St. Louis

(Volume I: Results)

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Low-Cost Application of the Model to Future-Year SIP Control and Alternative Fuel Strategies for Dallas-Fort Worth, Atlanta, Philadelphia, and St. Louis

(Volume I: Results)

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1 INTRODUCTION

The job of reducing ozone concentrations to levels below the National Ambient Air Quality Standard (NAAQS) has proven to be far more difficult than was thought when the Clean Air Act was passed and amended. The level of ozone precursor emissions remains too high; either emission reductions have been too small or have been required of the wrong sources, or both.

A plethora of technical explanations has been offered for failure to attain the ozone standard. These include perceived weaknesses in the attainment planning process (Federal Register, Vol. 52, No. 226, November 24, 1987; OTA 1988a,b,c), incomplete understanding or recognition of the anthropogenic and natural factors that cause elevated tropospheric ozone levels (Science, 1988), the failure to consider the effects of natural emissions (Chameides et al., 1988; Morris et al., 1989b), use of a simplistic modeling approach (OTA, 1988a; Seinfeld, 1988a; Burton, 1988), and failure to reduce the amount of emissions intended, either through overestimates of the effectiveness of control technology or failure to account for certain categories of emission sources. The EPA, after lengthy consideration, has proposed a comprehensive policy that includes major changes in the planning process for reducing ozone concentrations (Federal Register, Vol. 52, No. 226, November 24, 1987). These changes include improvements in modeling practices and requirements for improving the data to support improved modeling practices. The EPA is now evaluating public comments on the proposed policy.

USE OF THE URBAN AIRSHED MODEL

The EPA recommends that states use the Urban Airshed Model (UAM) for the modeling of ozone and photochemical reactive pollutants in urban areas (EPA, 1986). An alternative approach, the Empirical Kinetics Modeling Approach (EKMA), has been accepted for demonstrating attainment of the ozone standard in most State Implementation Plans (Federal Register, Vol. 52, No. 226, 1987). The UAM and EKMA are quite different types of models; the UAM is a three-dimensional grid model while the EKMA is a trajectory box model.

A reluctance to use the UAM in the past is based on the perception that it requires using data from costly intensive measurement studies and requires extensive computational resources. Most of the cost of applying the UAM is attributed to the practice of conducting an extensive evaluation of UAM performance, which usually entails many diagnostic simulations. This evaluation enables us to understand why the UAM performs as it does for a particular application and, if deemed necessary, to take actions to improve model performance. Historically, it has been expected that the UAM will calculate hourly ozone concentrations to within approximately 15 to 20 percent of the observed peak value (Seinfeld, 1988a; Burton, 1988). More recent applications of the UAM to the Los Angeles basin have used routinely available meteorological data and predicted observed ozone levels with a high degree of skill (Seinfeld, 1988a; Burton, 1988; Hogo, Mahoney, and Yocke 1988). A recent application of the UAM to the New York metropolitan area used simple inputs, i.e., constant wind fields and mixing depths (Rao 1987).

This simplified use of the UAM, relying on routinely available data and reducing the requirement for strict evaluations of model performance, offers air quality managers a practical air quality assessment tool for identifying emission control strategies that demonstrate attainment of the ozone NAAQS. This simplified approach is called Practice-for-Low-Cost-Airshed-Application-for-Nonattainment-Regions (PLANR). The PLANR use of the UAM requires almost the same quantity and quality of inputs as EKMA, and the overall application cost is substantially reduced. The possible exception is the emissions inventory, which in PLANR applications should contain the same spatially (horizontally and vertically) and temporally varying emissions used in standard UAM applications (such detail is necessary to account for the differing reactivities of VOC emissions). However, local agencies generally have emissions inventories at hand; in addition, UAM input inventories can be readily estimated from existing national emissions inventories (e.g., the National Acid Precipitation Program 1980 and 1985 inventories). Knowledge of current emission rates is needed to estimate the emission controls required to achieve attainment of the ozone NAAQS.

The PLANR use of the UAM may not be appropriate for all nonattainment regions. When attainment is expected to be imminent, improved methods for using EKMA may be adequate. In other, more complex situations, such as the Los Angeles basin, the Houston region, and the New York Metropolitan area among others, the complexity of meteorological conditions and the emissions distribution and the severity of the ozone attainment problem probably require a more detailed application of the UAM. The application of UAM to these more complex situations, called Practice-of-Airshed-Application-in-Complex-Regions (PACR), would involve more extensive model performance requirements and hence more diagnostic simulations, and a resultant increase in costs. However, even for a complex nonattainment region, the PLANR approach would probably be more comprehensive and reliable than EKMA for estimating the controls needed to achieve ozone attainment.

THE "FIVE CITIES" UAM STUDY

The EPA has funded a study of the PLANR approach in five urban areas in the U.S. (New York, St. Louis, Atlanta, Philadelphia, and Dallas-Ft. Worth). The main objectives of this "Five Cities" study are to:

(1) Demonstrate the usefulness of PLANR for air quality planning;

(2) Determine the effects of alternative fuels and alternative Reid vapor pressure values for fuels on urban ozone concentrations;

(3) Demonstrate the use of PLANR to evaluate SIP control strategies and compare results with those obtained with EKMA; and

(4) Transfer the UAM model, modeling data bases, and applications technology to the states for use in future SIPs.

In addition, the study includes two city-specific analyses:

(1) For the St. Louis and Philadelphia areas, comparison of the PLANR use of the UAM (i.e., using only routinely available data) with applications of the UAM that use an extensive data base; and

(2) The effects of biogenic emissions on anthropogenic emission reductions in the Atlanta area.

Additional reports on the "Five Cities" study have documented the evaluation of alternative fuel emission scenarios for the New York metropolitan area and the city of St. Louis (Morris et al., 1990a), the use of the UAM to evaluate the effects of biogenic emissions for the Atlanta area (Morris et al., 1990b), the demonstration of the PLANR use of the UAM for the city of Atlanta and the Dallas-Fort Worth metroplex region (Morris et al., 1990c), and the evaluation of PLANR applications of UAM to the St. Louis and Philadelphia regions (Morris, Myers, and Carr, 1990). The latest version of the UAM, which incorporates the Carbon Bond IV (CB-IV) chemical mechanism (Gery, Whitten, and Killus, 1988) and an improved advection algorithm (Smolarkiewicz, 1983), with associated input data bases has also been installed on computer systems at the EPA Office of Air Quality and Planning Standards (OAQPS), the New York State Department of Environmental Conservation (NYSDEC), and the Georgia Air Protection Branch (GAPB). Plans are in place to install the model on computer systems at the Texas Air Control Board (TACB) and Maryland Department of Environment.

This report describes the analysis of future-year (1995) SIP control strategies in three cities (Dallas-Fort Worth, Atlanta, and St. Louis) and future-year alternative fuel scenarios (new gas vehicle regulations, 100 percent methanol powered vehicles, and 100 percent compressed natural gas powered vehicles) in three cities (Dallas-Fort Worth, Philadelphia, and St. Louis).

2 DEFINITION OF THE 1995 EMISSION SCENARIOS

The Urban Airhsed Model (UAM) requires that the emissions data be input in a specific and detailed format. There are two types of UAM emissions files: a low-level area source file (EMISSIONS) and an elevated point source file (PTSOURC). Emission rates in moles per hour need to be prescribed as species from the CB-IV chemical mechanism. Emissions from the low-level file are injected into the lowest vertical layer of the UAM, whereas, emissions from the elevated point source file are injected into the appropriate vertical layer(s) depending on plume rise estimates using the stack parameters (stack height, stack diameter, exit velocity, and exit temperature) and meteorological conditions (wind speed, temperature, temperature gradients, and height of the diffusion break) in the grid cell containing the stack for the hour in question.

The development of the meteorological year base case emission files for the four cities analyzed in this report is described elsewhere (Schere and Shreffler 1982: Cole et al., 1983; Haney and Braverman 1985; Morris et al., 1989a,b,c, Morris Myers, and Carr 1989). In this section we describe the development of the 1995 Base Case, SIP control strategies and alternative fuel emission scenarios. There were four types of 1995 emission scenarios:

> 1995 Base Case: A 1995 base case emission inventory was developed based on growth projections, increases in Vehicle Miles Traveled (VMT), fleet turnover, implementation of Inspection and Maintance (I/M) programs, and a reduction in the volatility of gasoline to a Reid Vapor Pressure (RVP) value of 9 psi;
>
> 1995 SIP Control Type A Strategies: These emission control strategies consist of uniform (across the board) anthropogenic VOC emission reductions from the 1995 base case;
>
> 1995 SIP Control Type B Strategies: These emission control strategies consists of source specific VOC and NO_x emissions reductions from the 1995 base case based on realistic assumptions of emission controls using current technology. Additional point source (utilities) NO_x emission reductions were also performed for some scenarios; and
>
> 1995 Alternative Fuel Scenarios: Based on information supplied by the EPA Office of Mobile Source (OMS) (see Appendix A) three separate alternative fuel scenarios were developed: new regulations for gas vehicles (new reg gas) based

on the current administrations proposal, 100 percent penetration of neat methanol powered vehicles (M100), and 100 percent penetrations of compressed natural gas vehicles (CNG).

The development of each of the 1995 emission scenarios is described in the following paragraphs.

1995 BASE CASE EMISSION SCENARIOS

The 1995 base case emission scenarios for Dallas-Fort Worth, Atlanta, Philadelphia, and St. Louis were developed starting with the 1985 NAPAP emission inventory (Zimmerman et al., 1989) using the UAM Emissions Processing System (EPS) (SAI, 1989). Figure 2-1 shows the steps required to project the 1985 NAPAP inventory to 1995. Emission growth and VMT growth factors were obtained from E. H. Pechan and associates (Pechan, 1988). The adjustment of mobile source emissions from 1985 MOBILE3 to 1995 MOBILE4 includes annual to episodic temperature effects, addition of running losses, effects of tampering, changes in I/M policy and implementation of Stage II controls in some counties, and the effects of changes in RVP. For all cities studied a 9 psi RVP value was assumed for the 1995 emission scenarios. Note that RVP values of 10.7 and 10.4 psi were assumed for the 1985 base case emission inventories in, respectively, Atlanta and Dallas-Fort Worth.

The emissions totals for VOC and NO_x for the 1995 base case, 1995 Type B SIP control strategies, and 1995 alternative fuel scenarios and the four cities are given in Tables 2-1 through 2-4. Also included in these tables is information concerning the meteorological base year emission inventory.

1995 SIP CONTROL SCENARIOS

Two types of 1995 SIP control emission reduction strategies were examined: type A strategies are uniform (i.e., the same percentage reduction in each source category) anthropogenic emission reductions, and type B strategies are realistic technology-based VOC and NO_x emission reductions.

Type A 1995 SIP Control Strategies

Type A 1995 SIP emission control strategies were performed for two cities as follows:

Dallas-Fort Worth

30 percent anthropogenic VOC emission reduction

60 percent anthropogenic VOC emission reduction

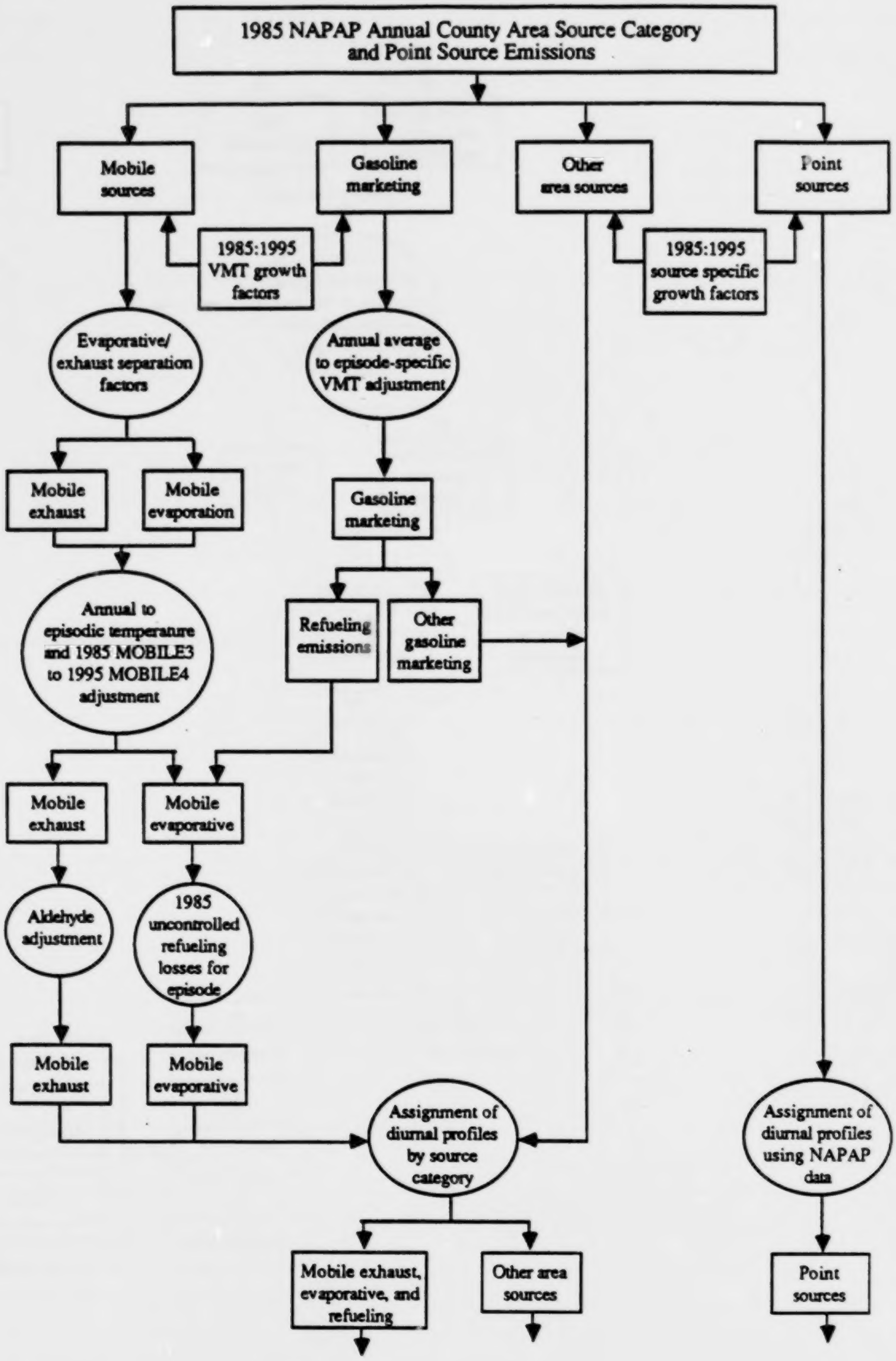
1985 NAPAP Annual County Area Source Category and Point Source Emissions
Mobile sources
Gasoline marketing
Other area sources
Point sources
1985:1995 VMT growth factors
1985:1995 source specific growth factors
Evaporative/ exhaust separation factors
Annual average to episode-specific VMT adjustment
Mobile exhaust
Mobile evaporation
Gasoline marketing
Refueling emissions
Other gasoline marketing
Annual to episodic temperature and 1985 MOBILE3 to 1995 MOBILE4 adjustment
Mobile exhaust
Mobile evaporative
Aldehyde adjustment
1985 uncontrolled refueling losses for episode
Mobile exhaust
Mobile evaporative
Assignment of diurnal profiles by source category
Assignment of diurnal profiles using NAPAP data
Mobile exhaust, evaporative, and refueling
Other area sources
Point sources

FIGURE 2-1. Glow diagram for creating the UAM 1985 base case low-level (EMISSIONS) and elevated (PTSOURC) emissions files.

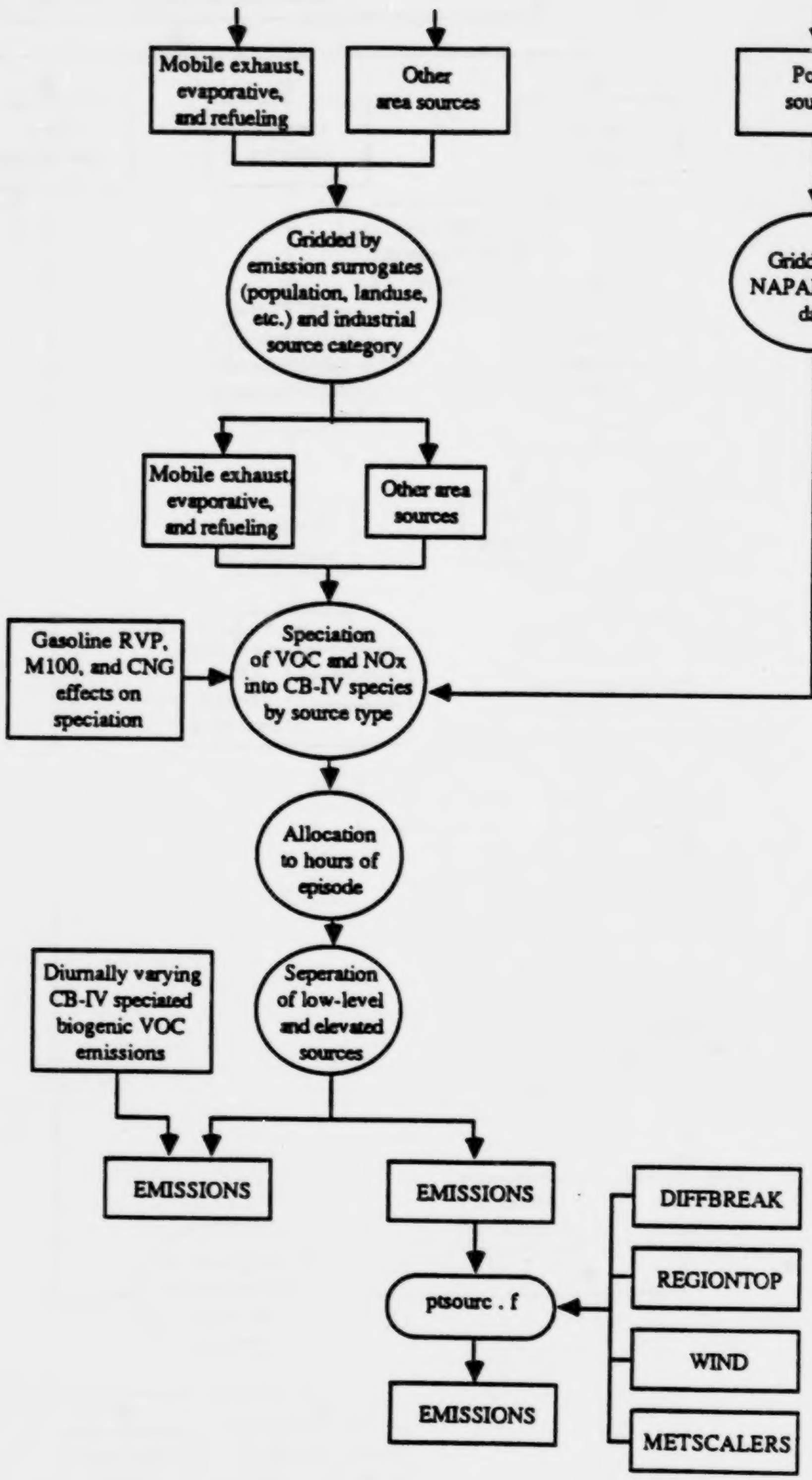
Mobile exhaust, evaporative, and refueling
Other area sources
Point sources
Gridded by emission surrogates (population, landuse, etc.) and industrial source category
Gridded by NAPAP UTM data
Mobile exhaust, evaporative, and refueling
Other area sources
Gasoline RVP, M100, and CNG effects on speciation
Speciation of VOC and NOx into CB-IV species by source type
Allocation to hours of episode
Diurnally varying CB-IV speciated biogenic VOC emissions
Seperation of low-level and elevated sources
EMISSIONS
EMISSIONS
DIFFBREAK
REGIONTOP
ptsourc . f
WIND
METSCALERS
EMISSIONS

FIGURE 2-1. Concluded.

ıBLE 2-1a. Total VOC emissions (tons per day, TPD) for the Dallas-Fort Worth emission scenarios.

ıission :enario	Area Sources TPD (%/%)^a	Mobile Sources TPD (%/%)^a	Low-Level Point TPD (%/%)^a	Elevated Point TPD (%/%)^a	Total Anthropogenic TPD (%)^b	Total Biogenic TPD (%)^b	Total Anthropogenic Plus Biogenic (TPD)
EKDAY							
85 Base	441 (31/21)	917 (64/43)	26 (2/1)	50 (3/2)	1434 (67)	694 (33)	2128
95 Base	545 (55/32)	372 (38/22)	70 (7/4)	4 (0/0)	991 (59)	694 (41)	1685
95 Scenario #1	307 (41/21)	372 (54/26)	70 (10/5)	4 (1/0)	753 (52)	694 (48)	1447
95 Scenario #2	307 (41/21)	372 (54/26)	70 (10/5)	4 (1/0)	753 (52)	694 (48)	1447
95 New Reg. Gas	545 (64/35)	231 (27/15)	70 (8/5)	4 (0/0)	850 (56)	694 (45)	1544
95 M100	545 (75/38)	110 (15/8)	70 (10/5)	4 (1/0)	729 (51)	694 (49)	1423
95 CNG	545 (83/40)	35 (5/3)	70 (11/5)	4 (1/0)	654 (49)	694 (51)	1348
EKEND							
85 Base	244 (25/14)	688 (69/41)	11 (1/1)	50 (5/3)	993 (54)	694 (41)	1687
95 Base	294 (50/23)	279 (47/22)	17 (3/1)	1 (0/0)	591 (46)	694 (54)	1285
95 Scenario #1	180 (38/15)	279 (58/24)	17 (4/1)	1 (0/0)	477 (41)	694 (59)	1171
95 Scenario #2	180 (38/15)	279 (58/24)	17 (4/1)	1 (0/0)	477 (41)	695 (59)	1171
95 New Reg. Gas	294 (60/25)	174 (36/15)	17 (3/1)	1 (0/0)	486 (41)	694 (59)	1180
95 M100	294 (75/27)	82 (21/8)	17 (4/2)	1 (0/0)	394 (36)	694 (64)	1088
95 CNG	294 (87/28)	26 (8/3)	17 (5/2)	1 (0/0)	338 (33)	694 (67)	1032

Percent of anthropogenic emissions/percent of total (anthropogenic and biogenic) emissions.
Percent of total emissions.

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TABLE 2-1b. Total NO_x emissions (tons per day, TPD) for the Dallas-Fort Worth emission scenarios.

Emission Scenario	Area Sources TPD (%)*	Mobile Sources TPD (%)*	Low-Level Point TPD (%)*	Elevated Point TPD (%)*	Total Anthropogenic TPD (%)*	Total Biogenic TPD (%)*	Total Anthropogenic Plus Biogenic (TPD)
WEEKDAY							
1985 Base	309 (35)	382 (43)	20 (2)	179 (20)	890 (100)	0	890
1995 Base	346 (41)	245 (29)	34 (4)	227 (27)	852 (100)	0	852
1995 Scenario #1	346 (50)	113 (16)	34 (5)	194 (28)	687 (100)	0	687
1995 Scenario #2	113 (16)	113 (16)	34 (5)	173 (25)	433 (100)	0	433
1995 New Reg. Gas	346 (41)	238 (28)	34 (4)	227 (27)	845 (100)	0	845
1995 M100	346 (41)	238 (28)	34 (4)	227 (27)	845 (100)	0	845
1995 CNG	346 (41)	238 (28)	34 (4)	227 (27)	845 (100)	0	845
WEEKEND							
1985 Base	261 (35)	287 (38)	19 (3)	179 (24)	746 (100)	0	746
1995 Base	293 (40)	184 (25)	33 (4)	227 (31)	737 (100)	0	737
1995 Scenario #1	293 (49)	84 (14)	33 (5)	194 (32)	604 (100)	0	604
1995 Scenario #2	106 (27)	84 (21)	33 (8)	173 (44)	396 (100)	0	396
1995 New Reg. Gas	293 (40)	179 (24)	33 (5)	227 (31)	732 (100)	0	732
1995 M100	293 (40)	179 (24)	33 (5)	227 (31)	732 (100)	0	732
1995 CNG	293 (40)	179 (24)	33 (5)	227 (31)	732 (100)	0	732

9.

* Percent of total emissions.

TABLE 2-2a. Total VOC emissions (tons per day, TPD) as methane for the Atlanta emission scenarios.

Emission Scenario	Area, Mobile, and Low-Level Point Sources TPD	(%/%)[a]	Elevated Point Sources TPD	(%/%)[a]	Total Anthropogenic TPD	(%)[b]	Total Biogenic TPD	(%)[b]	Total Anthropogenic Plus Biogenic (TPD)
1985 Base Case	NA	NA	NA	NA	1030	(45)	1277	(55)	2307
1995 Base Case	651	(97/33)	19	(3/1)	670	(33)	1277	(66)	1947
1995 Scenario #1	533	(97/29)	19	(3/1)	552	(30)	1277	(70)	1829
1995 Scenario #2	533	(97/29)	19	(3/1)	553	(30	1277	(70)	1829

[a] Percent of anthropogenic emissions/percent of total (anthropogenic plus biogenic) emissions.
[b] Percent of total emissions.

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TABLE 2-2b. Total NO_x emissions (tons per day, TPD) for the Atlanta emission scenarios.

Emission Scenario	Area Sources TPD	(%/%)	Elevated Point TPD	(%/%)	Total Anthropogenic TPD	(%)	Total Biogenic TPD (%)	Total Anthropogenic Plus Biogenic (TPD)
1985 Base Case	NA	NA	NA	NA	751	(100)	0	751
1995 Base Case	292	(36/36)	527	(64/64)	819	(100)	0	819
1995 Scenario #1	143	(34/34)	274	(66/66)	417	(100)	0	417
1995 Scenario #2	184	(33/33)	375	(67/67)	559	(100)	0	559

TABLE 2-3a. Total VOC emissions (tons per day, TPD) as methane for the St. Louis emission scenarios.

Emission Scenario	Area Sources TPD (%/%)[a]	Mobile Sources TPD (%/%)[a]	Low-Level Point TPD (%/%)[a]	Elevated Point TPD (%/%)[a]	Total Anthropogenic[b] TPD (%)	Total Biogenic[b] TPD (%)	Total Anthropogenic Plus Biogenic[b] (TPD)
1976 Base	272[b] (41/41)	377[b] (57/57)	NA	7[b] (1/1)	656 (100)	0[c]	646
1995 Base	287 (52/45)	114 (21/18)	125 (23/20)	23 (4/4)	549 (86)	90 (14)	639
1995 Scenario #1	154 (37/30)	114 (27/23)	125 (30/25)	23 (6/5)	416 (82)	90 (18)	506
1995 Scenario #2	154 (37/30)	114 (27/23)	125 (30/25)	23 (6/5)	416 (82)	90 (18)	506
1995 New Reg. Gas	287 (57/48)	69 (14/12)	125 (25/21)	23 (5/4)	504 (85)	90 (15)	594
1995 M100	287 (60/51)	41 (9/7)	125 (26/22)	23 (5/4)	476 (84)	90 (16)	566
1995 CNG	287 (64/53)	12 (3/2)	125 (27/23)	23 (5/4)	447 (83)	90 (17)	537

[a] Percent of anthropogenic emissions/percent of total (anthropogenic and biogenic) emissions.
[b] From Cole et al., 1983.
[c] Biogenic emissions were not included in the 1976 inventory.

TABLE 2-3b. Total NO_x emissions (tons per day, TPD) for the St. Louis emission scenarios.

Emission Scenario	Area Sources TPD (%)[a]	Mobile Sources TPD (%)[a]	Low-Level Point TPD (%)[a]	Elevated Point TPD (%)[a]	Total Anthropogenic TPD (%)[a]	Total Biogenic TPD (%)[a]	Total Anthropogenic Plus Biogenic (TPD)
1976 Base	305[b] (21)	344[b] (23)	NA	819[b] (56)	1468 (100)	0	1468
1995 Base	56 (13)	128 (30)	10 (2)	299 (54)	423 (100)	0	423
1995 Scenario #1	56 (18)	61 (19)	10 (3)	188 (60)	315 (100)	0	315
1995 Scenario #2	24 (9)	61 (23)	10 (4)	166 (64)	261 (100)	0	261
1995 New Reg. Gas	56 (14)	116 (28)	10 (2)	229 (56)	441 (100)	0	441
1995 M100	56 (14)	116 (28)	10 (2)	229 (56)	441 (100)	0	441
1995 CNG	56 (14)	116 (28)	10 (2)	229 (56)	441 (100)	0	441

[a] Percent of total (anthropogenic and biogenic) emissions.

[b] From Cole et al., 1983.

TABLE 2-4a. Total VOC emissions (tons per day, TPD) as methane for the Philadelphia emission scenarios.

Emission Scenario	Area Sources TPD (%/%)[a]	Mobile Sources TPD (%/%)[a]	Low-Level Point TPD (%/%)[a]	Elevated Point TPD (%/%)[a]	Total Anthropogenic TPD (%)[b]	Total Biogenic TPD (%)[b]	Total Anthropogenic Plus Biogenic (TPD)
1979 Base	1122[c] (96/96)	NA	NA	41 (4/4)	1163	NA[d]	1163
1995 Base	1213 (58/45)	505 (24/19)	231 (11/9)	134 (6/5)	2083 (77)	631 (23)	2714
1995 New Reg. Gas	1213 (65/48)	302 (16/12)	231 (12/9)	134 (7/5)	1880 (75)	631 (25)	2511
1995 M100	1213 (68/50)	197 (11/8)	231 (13/10)	134 (8/6)	1775 (74)	631 (26)	2406
1995 CNG	1213 (75/54)	49 (3/2)	231 (14/10)	134 (8/6)	1627 (72)	631 (28)	2258

[a] Percent of anthropogenic emissions/percent of total (anthropogenic plus biogenic) emissions.

[b] Percent of total (anthropogenic plus biogenic) emissions.

[c] 1979 area source category includes area sources, mobile sources, and low-level point sources.

[d] 1979 emission scenario did not include biogenics emissions.

TABLE 2-4b. Total NO_x emissions (tons per day, TPD) for the Philadelphia emission scenarios.

Emission Scenario	Area Sources TPD (%)[a]	Mobile Sources TPD (%)[a]	Low-Level Point TPD (%)[a]	Elevated Point TPD (%)	Total Anthropogenic TPD (%)[a]	Total Biogenic TPD (%)[a]	Total Anthropogenic Plus Biogenic (TPD)
1979 Base	610[b] (57)	NA	NA	467 (43)	1077 (100)	0	1077
1995 Base	181 (13)	561 (41)	92 (7)	551 (40)	1385 (100)	0	1385
1995 New Reg. Gas	181 (16)	328 (28)	92 (8)	551 (48)	1152 (100)	0	1385
1995 M100	181 (16)	328 (28)	92 (8)	551 (48)	1152 (100)	0	1385
1995 CNG	181 (16)	328 (28)	92 (8)	551 (48)	1152 (100)	0	1385

[a] Percent of total (anthropogenic plus biogenic) emissions.
[b] 1979 area source category includes area sources, mobile sources, and low-level point sources.

Atlanta

30 percent anthropogenic VOC emission reduction
60 percent anthropogenic VOC emission reduction
90 percent anthropogenic VOC emission reduction

As reported elsewhere, type A VOC emission control strategies for the meteorological base year were also performed for the city of Atlanta (Morris et al., 1989b), Philadelphia (Morris, Myers, and Carr, 1989), and St. Louis (Morris, Myers, and Carr, 1989).

Type B 1995 SIP Control Strategies

The realistic currently available technology based emission control strategies for the type B SIP control strategies were developed from the South Coast Air Quality Management Districts (SCAQMD) tier 1 emission control strategies from their Air Quality Management Plan (AQMP) (Hogo, Mahoney, and Yocke, 1988). Individual source catgories are targeted for emission reductions based on the current technology of emission control equipment for the particular source category in question. Table 2-5 lists the emission control factor for each source category in the NAPAP emission inventory. An emission control factor is the fraction of the emission to be reduced (i.e., a 0.15 emission control factor results in an emission rate from that source that is 85 percent of its original value).

The amount of VOC emission reduction in all the Type B SIP control strategies was based on the emission reductions from implementation of the tier 1 control factors as listed in Table 2-5. Additional NO_x emission reductions from some source categories, in addition to those listed in Table 2-5, were also implemented in order to reach targeted NO_x emission reductions for the different scenarios. Since each city has its own unique mix of sources, the source categories whose NO_x emissions were reduced varied from city to city.

Dallas Fort-Worth

Two type B SIP control strategies were developed for Dallas-Fort Worth (see Table 2-1):

Scenario #1:	24 percent reduction in anthropogenic VOC emissions, and 20 percent reduction in anthropogenic NO_x emissions.
Scenario #2:	24 percent reduction in anthropogenic VOC emissions, and 50 percent reduction in anthropogenic NO_x emissions.

TABLE 2-5. NAPAP area source category codes and "Tier 1" emission control factors.

Source Category Code	Category Description	Emission Control Factor	
		NO_x	VOC
1	Residential Fuel - Anthracite Coal	0.00	0.11
2	Residential Fuel - Bituminous Coal	0.00	0.11
3	Residential Fuel - Distillate Oil	0.00	0.11
4	Residential Fuel - Residual Oil	0.00	0.11
5	Residential Fuel - Natural Gas	0.00	0.11
6	Residential Fuel - Wood	0.00	0.11
7	Commercial/Institutional Fuel - Anthracite Coal	0.00	0.25
8	Commercial/Institutional Fuel - Bituminous Coal	0.00	0.25
9	Commercial/Institutional Fuel - Distillate Oil	0.00	0.25
10	Commercial/Institutional Fuel - Residual Oil	0.00	0.25
11	Commercial/Institutional Fuel - Natural Gas	0.00	0.25
12	Commercial/Institutional Fuel - Wood	0.00	0.25
13	Industrial Fuel - Anthracite Coal	0.00	0.15
14	Industrial Fuel - Bituminous Coal	0.00	0.15
15	Industrial Fuel - Coke	0.00	0.15
16	Industrial Fuel - Distillate Oil	0.00	0.15
17	Industrial Fuel - Residual Oil	0.00	0.15
18	Industrial Fuel - Natural Gas	0.00	0.15
19	Industrial Fuel - Wood	0.00	0.15
20	Industrial Fuel - Process Gas	0.00	0.15
21	On-Site Incineration - Residential	0.00	0.00
22	On-Site Incineration - Industrial	0.00	0.00
23	On-site Incineration - Commercial/Institutional	0.00	0.00
24	Open Burning - Residential	0.00	0.00
25	Open Burning - Industrial	0.00	0.00
26	Open Burning - Commercial/Institutional	0.00	0.00
27	Light Duty Gasoline Vehicles - Limited Access Roads	0.65	0.00
28	Light Duty Gasoline Vehicles - Rural Roads	0.65	0.00
29	Light Duty Gasoline Vehicles - Suburban Roads	0.75	0.00
30	Light Duty Gasoline Vehicles - Urban Roads	0.75	0.00
31	Medium Duty Gasoline Vehicles - Limited Access Roads	0.45	0.00
32	Medium Duty Gasoline Vehicles - Rural Roads	0.45	0.00
33	Medium Duty Gasoline Vehicles - Suburban Roads	0.60	0.00
34	Medium Duty Gasoline Vehicles - Urban Roads	0.60	0.00
35	Heavy Duty Gasoline Vehicles - Limited Access Roads	0.50	0.00
36	Heavy Duty Gasoline Vehicles - Rural Roads	0.50	0.00
37	Heavy Duty Gasoline Vehicles - Suburban Roads	0.65	0.00
38	Heavy Duty Gasoline Vehicles - Urban Roads	0.65	0.00
39	Off Highway Gasoline Vehicles	0.00	0.50
40	Heavy Duty Diesel Vehicles - Limited Access Roads	0.45	0.00

continued

TABLE 2-5. continued.

Source Category Code	Category Description	Emission Control Factor	
		NO_x	VOC
41	Heavy Duty Diesel Vehicles - Rural Roads	0.45	0.00
42	Heavy Duty Diesel Vehicles - Suburban Roads	0.45	0.00
43	Heavy Duty Diesel Vehicles - Urban Roads	0.45	0.00
44	Off Highway Diesel Vehicles	0.00	0.00
45	Railroad Locomotives	0.00	0.90
46	Aircraft LTOs - Military	0.00	0.55
47	Aircraft LTOs - Civil	0.00	0.55
48	Aircraft LTOs - Commercial	0.00	0.55
49	Vessels - Coal	0.00	0.30
50	Vessels - Diesel Oil	0.00	0.30
51	Vessels - Residual Oil	0.00	0.30
52	Vessels - Gasoline	0.00	0.30
53[a]	Solvents Purchased (not used)	0.00	0.00
54	Gasoline Marketed	0.00	0.30
55	Unpaved Road Travel	0.00	0.00
56	Unpaved Airstrip LTOs	0.00	0.00
57	(Not used)	0.00	0.00
58	(Not used)	0.00	0.00
59	(Not used)	0.00	0.00
60	Forest Wild Fires	0.00	0.00
61	Managed Burning - Prescribed	0.00	0.00
62	Agricultural Field Burning	0.00	0.00
63	Frost control - Orchard Heaters	0.00	0.00
64	Structural Fires	0.00	0.00
65	(Not used)	0.00	0.00
66	Ammonia Emissions - Light duty Gasoline Vehicles	0.00	0.00
67	Ammonia Emissions - Heavy Duty Gasoline Vehicles	0.00	0.00
68	Ammonia Emissions - Heavy Duty Diesel Vehicles	0.00	0.00
69[b]	Livestock Waste Management - Turkeys	0.00	0.50
70[b]	Livestock Waste Management - Sheep	0.00	0.50
71[b]	Livestock Waste Management - Beef Cattle	0.00	0.50
72[b]	Livestock Waste Management - Dairy Cattle	0.00	0.50
73[b]	Livestock Waste Management - Swine	0.00	0.50
74[b]	Livestock Waste Management - Broilers	0.00	0.50
75[b]	Livestock Waste Management - Other Chickens	0.00	0.50
76[a]	Anhydrous Ammonia Fertilizer Application	0.00	0.60
77	Beef Cattle Feed Lots	0.00	0.50
78	Degreasing	0.00	0.55
79	Dry Cleaning	0.00	0.40
80	Graphic Arts/Printing	0.00	0.25

continued

TABLE 2-5. concluded.

Source Category Code	Category Description	Emission Control Factor	
		NO_x	VOC
81	Rubber and Plastics Manufacture	0.00	0.80
82	Architectural Coatings	0.00	0.75
83	Auto body Repair	0.00	0.95
84	Motor Vehicle Manufacture	0.00	0.65
85	Paper Coating	0.00	0.15
86	Fabricated Metals	0.00	0.25
87	Machinery Manufacture	0.00	0.25
88	Furniture Manufacture	0.00	0.80
89	Flatwood Products	0.00	0.55
90	Other Transportation Equipment Manufacture	0.00	0.40
91	Electrical Equipment Manufacture	0.00	0.00
92	Shipbuilding and Repairing	0.00	0.40
93	Miscellaneous Industrial Manufacture	0.00	0.35
94[c]	(Not used)	0.00	0.00
95[c]	Miscellaneous Solvent Use	0.00	0.35
96	(Not used)	0.00	0.25
97	(Not used)	0.00	0.25
98	(Not used)	0.00	0.25
99	(Not used)	0.00	0.25
100	Publicly Owned Treatment Works (POTWs)	0.00	0.00
101	Cutback Asphalt Paving Operation	0.00	0.90
102	Fugitives from Synthetic Organic Chemical Manufacture	0.00	0.15
103	Bulk Terminal and Bulk Plants	0.00	0.75
104	Fugitives from Petroleum Refinery Operations	0.00	0.60
105	Process Emissions from Bakeries	0.00	0.00
106	Process Emissions from Pharmaceutical Manufacture	0.00	0.15
107	Process Emissions from Synthetic Fibers Manufacture	0.00	0.00
108	Crude Oil and Natural Gas Production Fields	0.00	0.15
109	Hazardous Waste Treatment, Storage, and Disposal Facilities (TSDFs)	0.00	0.90

[a] SCC 53 is disaggregated into process categories 78 to 95.

[b] These categories formerly referred to as "manure field application."

[c] Formerly "miscellaneous industrial solvent use" (94) and "miscellaneous nonindustrial solvent use" (95); now combined into one category.

The VOC emission reductions for the two type B SIP control scenarios were a result of implementing the tier 1 emission control strategy (Table 2-5). For SIP control scenario #1 the tier 1 mobile source (i.e., source categories 27-38 and 40-43 in Table 2-5) control factors were implemented, resulting in a reduction of total anthropogenic NO_x emissions of 15 percent. In order to get the targeted NO_x emission reduction of 20 percent for scenario #1, elevated point sources were reduced 17 percent from the 1995 base case. For scenario #2 all tier 1 NO_x emission control factors were implemented along with a reduction in NO_x emissions from elevated sources of 24 percent from the 1995 base case.

Atlanta

The two type B SIP emission control strategies for Atlanta (see Table 2-2) were as follows:

Scenario #1:	18 percent reduction in anthropogenic VOC emissions, and 49 percent reduction in anthropogenic NO_x emissions.
Scenario #2:	18 percent reduction in anthropogenic VOC emissions, and 32 percent reduction in anthropogenic NO_x emissions.

For scenario #1 (49 percent reduction in NO_x emissions) all tier 1 VOC and NO_x controls for area sources were implemented (see Table 2-5). In addition, for scenario #1 a 50 percent reduction of NO_x emissions from power plants (SIC 4911) was also implemented. For the 32 percent reduction in NO_x emissions scenario (scenario #2) all of the tier 1 VOC controls were assumed along with tier 1 NO_x controls for on road motor vehicles (source categories 27-38 and 40-43). A 30 percent reduction in NO_x emissions from power plants was also applied for Atlanta SIP control scenario #2.

St. Louis

Two 1995 type B SIP controls strategies were also performed for St. Louis (see Table 2-3):

Scenario #1:	24 percent reduction in anthropogenic VOC emissions, and 26 percent reduction in anthropogenic NO_x emissions; and
Scenario #2:	24 percent reduction in anthropogenic VOC emissions, and 38 percent reduction in anthropogenic NO_x emissions.

For scenario #1, VOC emissions were reduced based on all of the tier 1 control factors for area sources (Table 2-5) and NO_x emissions were reduced by implementing the tier 1 emission reductions for mobile sources and reducing elevated point source NO_x emissions by 18 percent. In scenario #2 all tier 1 control factors for VOC and NO_x were implemented along with a 28 percent reduction in elevated NO_x emissions from the 1995 base case.

1995 ALTERNATIVE FUEL SCENARIOS

Three different 1995 alternative fuel scenarios were analyzed:

> New regulations for gasoline vehicles (new reg gas), based on a bill proposed by the current administration for reducing emissions from gasoline vehicles;
>
> 100 percent penetration of neat methanol (M100) powered vehicles, and
>
> 100 percent penetration of compressed natural gas (CNG) powered vehicles.

The procedures used to develop the 1995 alternative fuel emissions scenarios were provided by the EPA Office of Mobile Sources (EPA/OMS) and is presented in Appendix A. We followed the guidance from EPA/OMS for the alternative fuel scenarios with one exception; the reduction in VOC emissions from production, storage, and transfer of gasoline was not accounted for because insufficient information was available.

As noted in Appendix A, the three alternative fuel scenarios also assume a slower average vehicle speed (20 mph) than was assumed in the 1985 NAPAP inventory and the 1995 base case and 1995 SIP control strategies presented here. Because of this speed difference it is not really appropriate to compare the results from the 1995 alternative fuel scenarios with the 1995 base case and SIP control scenarios. However, we will compare results from the 1995 new regulation gas vehicles scenario with the 1995 base case in order to obtain an indication of the effects of the proposed new gasoline vehicle regulations. Care should be taken in the interpretation of the results. Note that estimates of exhaust emissions increase with decreasing vehicle speed.

It should also be noted that the 1995 M100 and 1995 CNG emission scenarios are somewhat hypothetical since it would be near impossible to switch over to all M100 and CNG vehicles in 5 years. In addition, the emission and speciation factors provided in Appendix A for the 1995 M100 and 1995 CNG scenarios assume emissions control technology that has not been demonstrated for an entire emissions fleet.

As listed in Tables 2-1, 2-3, and 2-4, the three 1995 alternative fuel scenarios were developed for three cities: Dallas-Fort Worth, St. Louis, and Philadelphia. The alternative fuel scenarios were not simulated for Atlanta for two reasons: (1) resource and time constraints; and (2) the large amount of biogenic VOC emissions in the Atlanta modeling domain overwhelm any anthropogenic VOC emission changes (see Morris et al., 1989b).

For Dallas-Fort Worth and St. Louis mobile source VOC emissions for the 1995 M100 scenario are 50 percent of the mobile source emissions for the 1995 new regulations for gas vehicles emissions scenario. For Philadlephia the 1995 M100 mobile source VOC emissions are only 35 percent lower than the 1995 new regulations emission scenario.

SPECIATION OF THE 1995 EMISSION SCENARIOS

The emission totals for the 1995 emission scenarios do not completely indicate the effects of the different fuel usage. The reactivity of the VOC emissions also is a big factor in a VOC emissions ability to produce ozone. The speciation of the 1995 gasoline scenarios followed the guidance given by Morris et al. (1989a), which has allowances for the RVP value. The speciation of the M100 and CNG emission scenarios followed the guidence from EPA/OMS (Appendix A) based on the results from the California Air Resources Board (CARB, 1988). One way to compare the reactivities of the different fuels is by calculating the average hydroxyl (OH) reactivity for the fuels in question. The hydroxyl reactivity is obtained by taking the sum over all CB-IV species of the product of the carbon fraction of each CB-IV VOC species, the number of carbons in the CB-IV species, and the hydroxyl reaction rate constant for that species. The speciation of the exhaust and evaporative mobile source emissions and the hydroxyl reactivity for the different fuels is given in Table 2-6.

Included in Table 2-6 is the speciation of two different gasoline fuels: the speciation from the Air Emissions Speciation Manual (AESM) (EPA, 1988) and the speciation used in the 1995 gasoline emission scenarios. The AESM speciation represents an average speciation of many different in use gasoline fuels whose RVP ranges from 8.4 psi to 12.3 psi with an average RVP value of about 11.4 psi. The 1995 gasoline fuel scenarios assumed an RVP value of 9.0 psi. The reactivity of the exhaust emissions for the AESM (11.4 psi) and 1995 (9 psi) gasoline fuels is almost identical with an hydroxyl reactivity rate of 3,107. However, evaporative emissions from the 9 psi gasoline fuel is more reactive (2,194) than the AESM gasoline (2,123).

Exhaust emissions from the 1995 M100 emission scenarios are approximately half as reactive (1,683) as those from the 1995 gasoline scenarios (3,107). While exhaust emissions from the 1995 CNG are over 20 times less reactive than the 1995 gasoline emission scenarios. For evaporative emissions, the reactivity of the 1995 M100 emissions is 30 percent less than the 1995 gasoline scenarios. The CNG vehicles do not emit any evaporative emissions.

TABLE 2-6. Speciation and hydroxyl reactivity for mobile sources and the different emission scenarios.

			Exhaust Emissions								Evaporative Emissions							
			AESM[a]		1995 Gas[b]		M100		CNG		AESM[a]		1995 Gas[b]		M100		CH	
Species	Number of Carbons	Hydroxyl Rate Constant at 298°K (1/ppm-min.)	Carbon[c] Fraction	Hydroxyl Weight	Carbon[c] Fraction	Hydroxyl Weight	Carbon[c] Fraction	Hydroxyl Weight	Carbon[c] Fraction	Hydroxyl Weight	Carbon[c] Fraction	Hydroxyl Weight	Carbon[c] Fraction	Hydroxyl Weight	Carbon[c] Fraction	Hydroxyl Weight	Carbon[c] Fraction	
OLE	2	42,000	4.25	893	4.25	893	0.16	33	0.21	43	1.97	413	2.11	444	0	0	0	
PAR	1	1,203	46.32	557	4.63	557	4.76	57	5.90	47	76.54	921	74.74	899	0	0	0	
TOL	7	9,150	9.95	130	9.95	130	1.78	25	0.07	1	10.55	138	11.36	148	0	0	0	
XYL	8	36,200	14.35	650	14.35	650	0.84	38	0.16	7	6.56	297	7.07	320	0	0	0	
HCHO	1	15,000	0.71	107	0.71	107	2.62	394	0.12	18	0	0	0	0	0	0	0	
ALD2	2	24,000	1.76	210	1.76	210	0.13	16	0.03	3	2.94	353	3.17	380	0	0	0	
ETH	2	11,920	8.54	509	8.54	509	0.18	11	0.18	11	0.03	2	0.03	2	0	0	0	
MEOH	1	1,380	0	0	0	0	80.45	1110	0	0	0	0	0	0	1.00	1380	0	
ETOH	2	4,300	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ISOP	5	142,000	0.18	50	0.18	50	0	0	0	0	0	0	0	0	0	0	0	0
NR	1	00	13.94	0	13.94	0	9.06	0	95.33	0	1.41	0	1.51	0	0	0	0	0
Total	--	--	1.00	3107	1.00	3107	1.00	1683	1.00	130	1.00	2123	1.00	2194	1.00	1380	0	0

[a] Air Emissions Speciation Manual (AESM) (EPA, 1988); speciation based on a 11.4 psi RVP value.

[b] All 1995 gasoline scenarios assumed a 9 psi RVP value.

[c] Carbon fraction presented in percent.

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3 APPLICATION OF THE UAM TO THE 1995 EMISSION SCENARIOS

In this section we discuss the UAM results for the 1995 Base Case, the 1995 SIP control strategies, and the 1995 alternative fuel scenarios. Because a photochemical grid model, such as the UAM, produces large amounts of output, we have limited our discussion to the primary species of interest, ozone. We present the results for the 1995 emission scenarios in three different forms: (1) tables of predicted region-wide maximum ozone concentrations; (2) isopleths of predicted daily maximum ozone concentrations and differences of predicted daily maximum ozone concentrations between different emission scenarios where appropriate; and (3) isopleths of hourly ozone concentrations and isopleths of differences in hourly ozone concentrations where appropriate. The predicted hourly ozone concentrations are presented in the appendixes in Volume II of this report.

Analyses of future-year alternative emission scenarios should also include the effects of the emission changes on population exposure, areal extent of exceedances, 6- and 8-hour average ozone concentrations, and other species (e.g., NO_2, PAN, nitric acid, PM-10, etc.). However, time and resource constraints have limited our discussion here to how the emission scenarios affect hourly ozone concentrations.

1995 SIP CONTROL STRATEGIES

The UAM results for 1995 base case and type A and type B SIP control strategies are discussed for three cities: Dallas-Fort Worth, Atlanta, and St. Louis.

Dallas-Fort Worth

1995 Base Case

As seen in Figure 3-1 and Table 3-1, the predicted peak maximum ozone concentration on 30 August for the Dallas-Fort Worth 1995 base case is 11.6 pphm and occurs west of Fort Worth. On 31 August the 1995 base case peak ozone concentration is 13.7 and occurs in Dallas. Isopleths of the predicted hourly ozone concentrations for the Dallas-Fort Worth 1995 base case are presented in Appendix B. On both August 30 and 31 there is a lot of spatial variability in the predicted daily maximum ozone concentrations (Figure 3-1), the predicted ozone concentrations vary by over a factor of two within a distance of 12 km (3 grid cells).

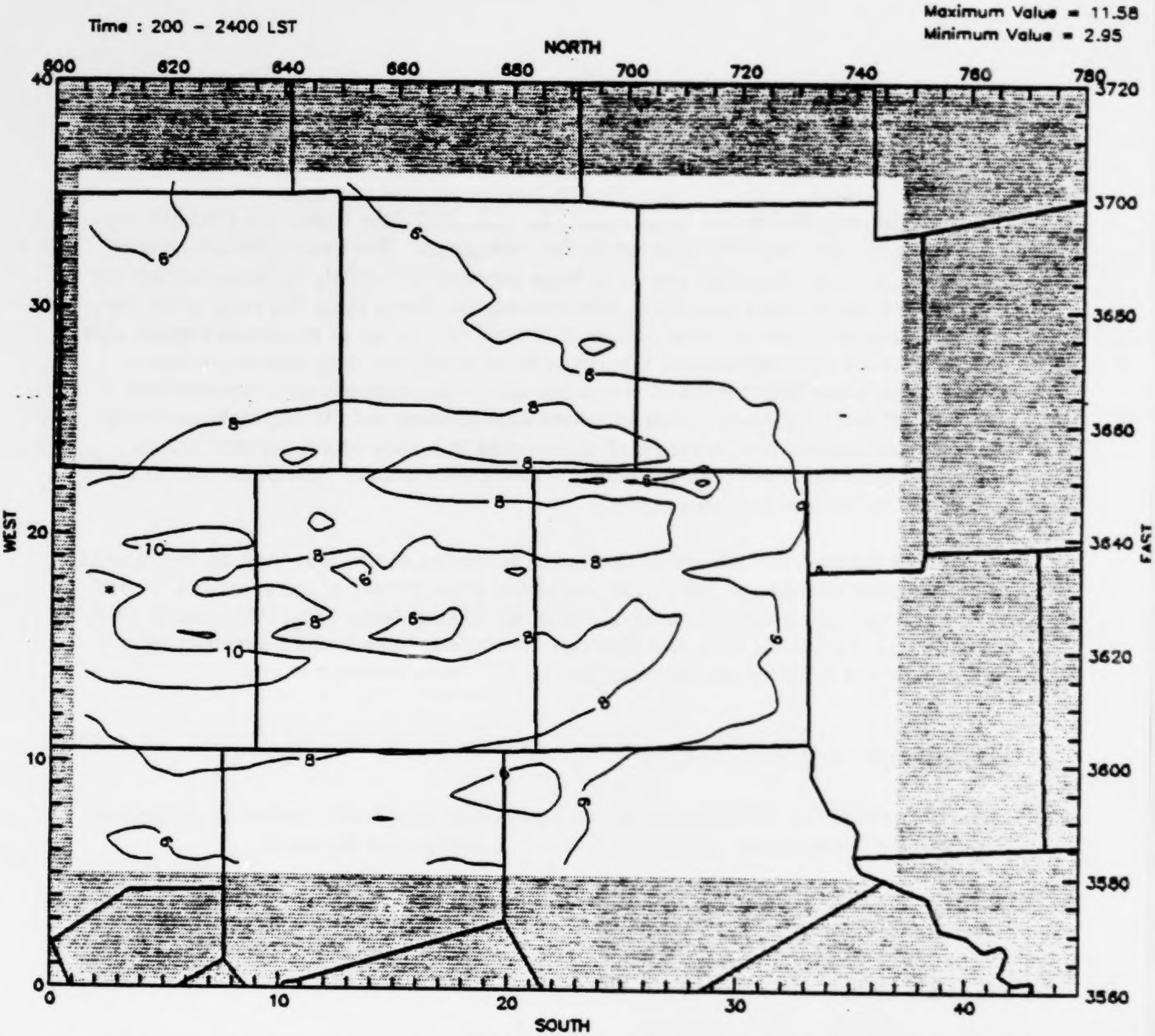
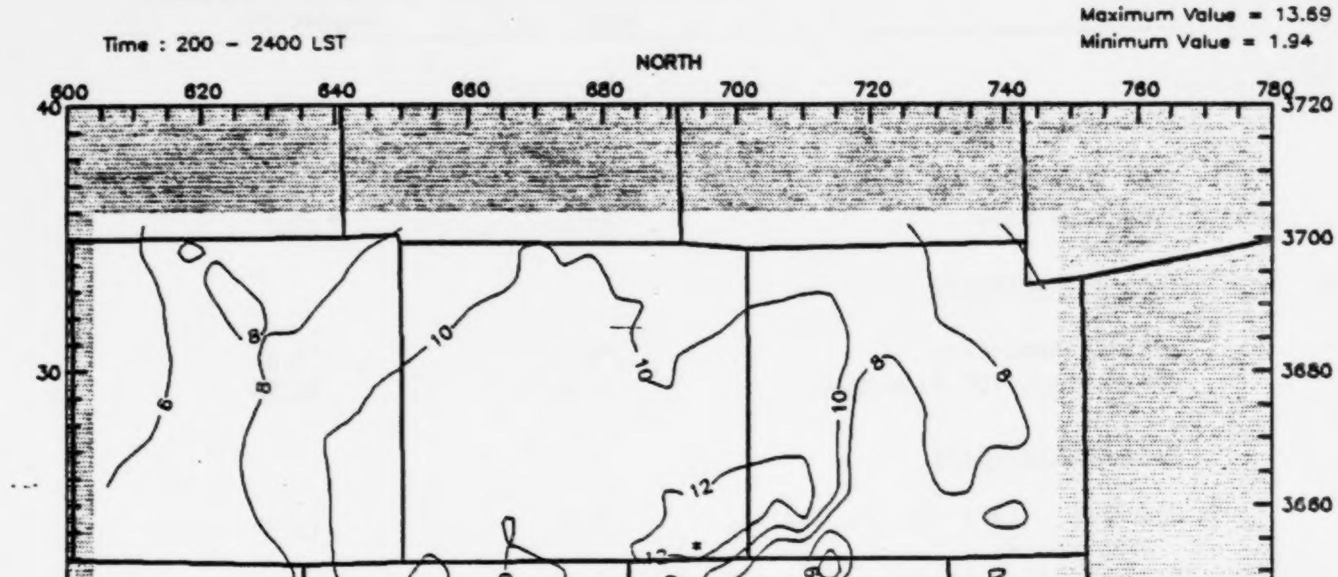

Time : 200 - 2400 LST
Maximum Value = 11.58
Minimum Value = 2.95
NORTH
600
620
640
660
680
700
720
740
760
780
3720
3700
3680
3660
3640
3620
3600
3580
3560
EAST
WEST
40
30
20
10
0
SOUTH
0
10
20
30
40
6
8
10

FIGURE 3-1a. Predicted Daily Maximum Ozone Concentration (pphm) in Dallas-Fort Worth on 30 August 1985 for 1995 Base Case Emission Scenario


Maximum Value = 13.69
Minimum Value = 1.94
Time : 200 - 2400 LST
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640
660
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700
720
740
760
780
3720
3700
3680
3660
3640
3620
3600
3580
3560
EAST
WEST
40
30
20
10
0
10
20
30
40
SOUTH
6
8
10
12

FIGURE 3-1b. Predicted Daily Maximum Ozone Concentration (pphm) in Dallas-Fort Worth on 31 August 1985 for 1995 Base Case Emission Scenario

TABLE 3-1. Predicted region-wide maximum ozone concentrations for the base cases and the 1995 SIP control strategies.

	Predicted Peak Ozone Concentration (pphm)	
	August 30	August 31
(a) Dallas-Fort Worth		
Emission Scenario		
1985 Base Case	13.2	16.4
1995 Base Case	11.6	13.7
Type A Strategies		
30% VOC Reduction	10.0	11.6
60% Percent VOC Reduction	8.9	10.8
Type B Strategies		
Scenario 1 (24% VOC and 19% NO_x Reductions)	10.8	13.3
Scenario 2 (24% VOC and 49% NO_x Reductions)	12.8	13.4
(b) Atlanta		
	June 4	
Emission Scenario		
1985 Base Case	13.2	
1995 Base Case	12.5	
Type A Strategies		
30% VOC Reduction	11.9	
60% VOC Reduction	11.1	
90% VOC Reduction	10.6	

TABLE 3-1. Concluded.

	Predicted Peak Ozone Concentration (pphm)
Type B Strategies	
Scenario 1 (18% VOC and 49% NO_x Reductions)	10.8
Scenario 2 (18% VOC and 32% NO_x Reductions)	11.3
	(c) St. Louis
	13 July
Emission Scenario	
1976 Base Case	24.4
1995 Base Case	14.5
Type B Strategies	
1995 Scenario #1 (24% VOC and 26% NO_x reduction)	13.3
1995 Scenario #2 (24% VOC and 38% NO_x reduction	13.4

As seen in Table 3-2, the 1995 base case anthropogenic emission inventory has a VOC-to-NO_x ratio of 2.3 (weekend) to 3.3 (weekday). When biogenic emissions are included the emission inventory VOC-to-NO_x ratio ranges from 5.0 (weekend) to 5.7 (weekday). The 1985 Base Case emission scenario emission inventory VOC-to-NO_x ranges ranged from 3.8 to 4.6 (anthropogenic only) and 6.5 to 6.9 (anthropogenic plus biogenic). The 1985 median measured morning VOC-to-NO_x ratio was 11.8 (Lonneman, 1986; Bauges 1986; Chang et al., 1989). There are several reasons why ambient measurements of VOC-to-NO_x ratios are always higher than the ratios in the emission inventory: (1) a large percentage of the NO_x emissions are from elevated sources which would not be mixed down to the ground during the 6 to 9 a.m. morning measurement period; (2) the measurements are usually made in the downtown urban core which is dominated by VOC emissions; and (3) NO_x concentrations are removed from the atmosphere through chemical reactions and deposition faster then VOC species. The VOC-to-NO_x ratio, either measured or in the inventory, is frequently used to indicate whether VOC emission controls (during low VOC-to-NO_x conditions) or NO_x emission controls (during high VOC-to-NO_x conditions) will be more effective for reducing ozone concentrations. However, because the VOC-to-NO_x ratio varies spatially and temporally it is not always a good indicator of emission control strategies; which is why a model that accounts for these variations, such as the UAM, is needed to evaluate emission control strategies.

Type A SIP Control Strategies

As seen in Table 3-1 and 3-2, a 30 and 60 percent reduction in the 1995 base case anthropogenic VOC emissions results in a 13.8 and 23.3 percent reduction in the peak ozone concentration, respectively. At these fairly low VOC-to-NO_x ratios in the inventory (less than 5) VOC emission controls should be more effective at reducing ozone concentrations then NO_x emission controls.

Type B SIP Control Strategies

For the 1995 scenario #1 (24 percent reduction in VOC emissions and 19 percent reduction in NO_x emissions) the peak ozone concentration is reduced by 6.9 percent on 30 August and 2.9 percent on 31 August. Based on the type A SIP control strategies (VOC emission reductions only), it is estimated that the 24 percent reduction in VOC emissions with no change in NO_x emission would result in an approximate 11 percent decrease in the peak ozone concentration. Thus it appears the 19 percent reduction in NO_x emissions hinders some of the benefits for reducing ozone concentrations due to the VOC emission reductions.

Isopleths of the daily maximum ozone concentrations for scenario #1 are given in Figure 3-2, whereas deficit enhancement (DE) plots of the differences in daily maximum ozone concentrations between 1995 scenario #1 and the 1995 base case are

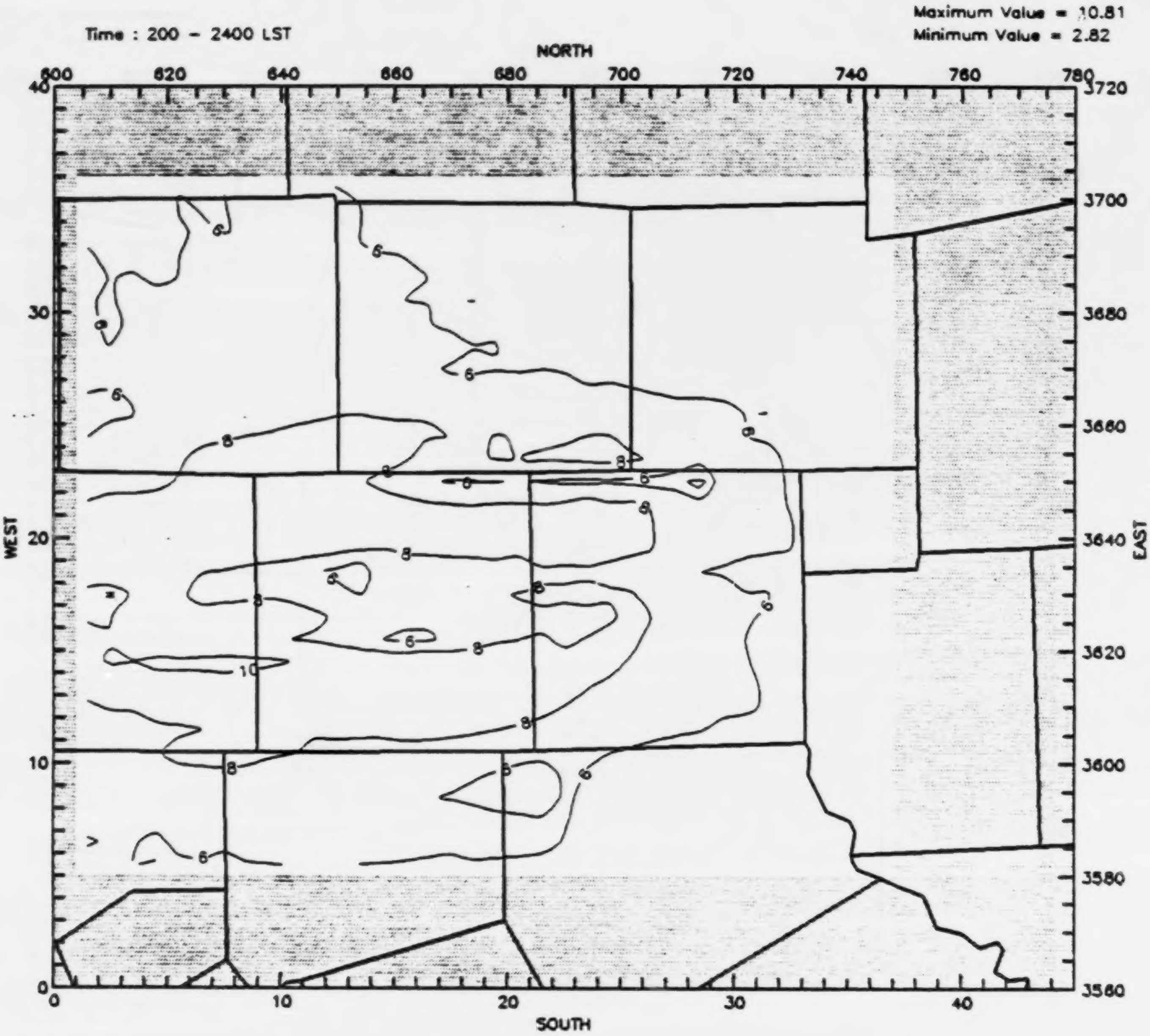
.BLE 3-2. VOC-to-NO_x ratios, changes in emissions, and changes in peak ozone concentrations for the base cases at 1995 SIP control strategies.

Emission Scenario	VOC-to-NO_x Ratio			Percent Change in Anthropogenic Emissions from the 1995 Base Case		Percent Change in Peak Ozone Concentration from 1995 Base Case
	Emissions Anthropogenic	Anthropogenic Plus Biogenic Emissions	Median Measured 1985	VOC	NO_x	
(a) Dallas-Fort Worth, 30 August 1985						
1985 Base Case	4.6	6.9	11.8	+45	+4	+13.8
1995 Base Case	3.3	5.7	11.8	0	0	0
Type A Strategies						
1995 30% VOC Reduction	2.3	4.7	11.8	-30	0	-13.8
1995 60% VOC Reduction	1.3	3.7	11.8	-60	0	-23.3
Type B Strategies						
1995 Scenario #1	3.2	6.1	11.8	-24	-19	-6.9
1995 Scenario #2	4.6	9.6	11.8	-24	-49	+9.4
(b) Dallas-Fort Worth, 31 August 1985						
1985 Base Case	3.8	6.5	11.8	+68	+1	+19.7
1995 Base Case	2.3	5.0	11.8	0	0	0
Type A Strategies						
1995 30% VOC Reduction	1.6	4.3	11.8	-30	0	-15.3
1995 60% VOC Reduction	0.9	1.3	11.8	-60	0	-21.2
Type B Strategies						
1995 Scenario #1	2.3	5.6	11.8	-19	-18	-2.9
1995 Scenario #2	3.5	8.5	11.8	-19	-46	-2.2

continued

TABLE 3-2. Concluded.

	VOC-to-NO_x Ratio			Percent Change in Anthropogenic Emissions from the 1995 Base Case		Percent Change in Peak Ozone Concentration from 1995 Base Case
Emission Scenario	Emissions Anthropogenic	Anthropogenic Plus Biogenic Emissions	Median Measured 1985	VOC	NO_x	
(c) Atlanta, 4 June 1984						
1985 Base Case	3.9	8.8	10.4	-35	-8	NA
1995 Base Case	6.8	11.3	10.4	0	0	0
Type A Strategies						
1995 30% VOC Reduction	4.8	9.3	10.4	-30	0	-4.8
1995 60% VOC Reduction	2.7	7.2	10.4	-60	0	-11.2
1995 90% VOC Reduction	0.7	5.2	10.4	-90	0	-15.2
Type B Strategies						
1995 Scenario #1	12.6	21.4	10.4	-18	-49	-13.6
1995 Scenario #2	9.4	16.0	10.4	-18	-32	-9.6
(d) St. Louis, 13 July 1976						
1976 Base Case	1.3	1.3*	9.6	+19	+247	NA
1995 Base Case	3.7	4.3	9.6	0	0	0
Type B Strategies						
1995 Scenario #1	3.8	4.6	9.6	-24	-26	-8.3
1995 Scenario #2	4.6	5.6	9.6	-24	-38	-7.6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Minimum Value = 2.82
NORTH
SOUTH
WEST
EAST
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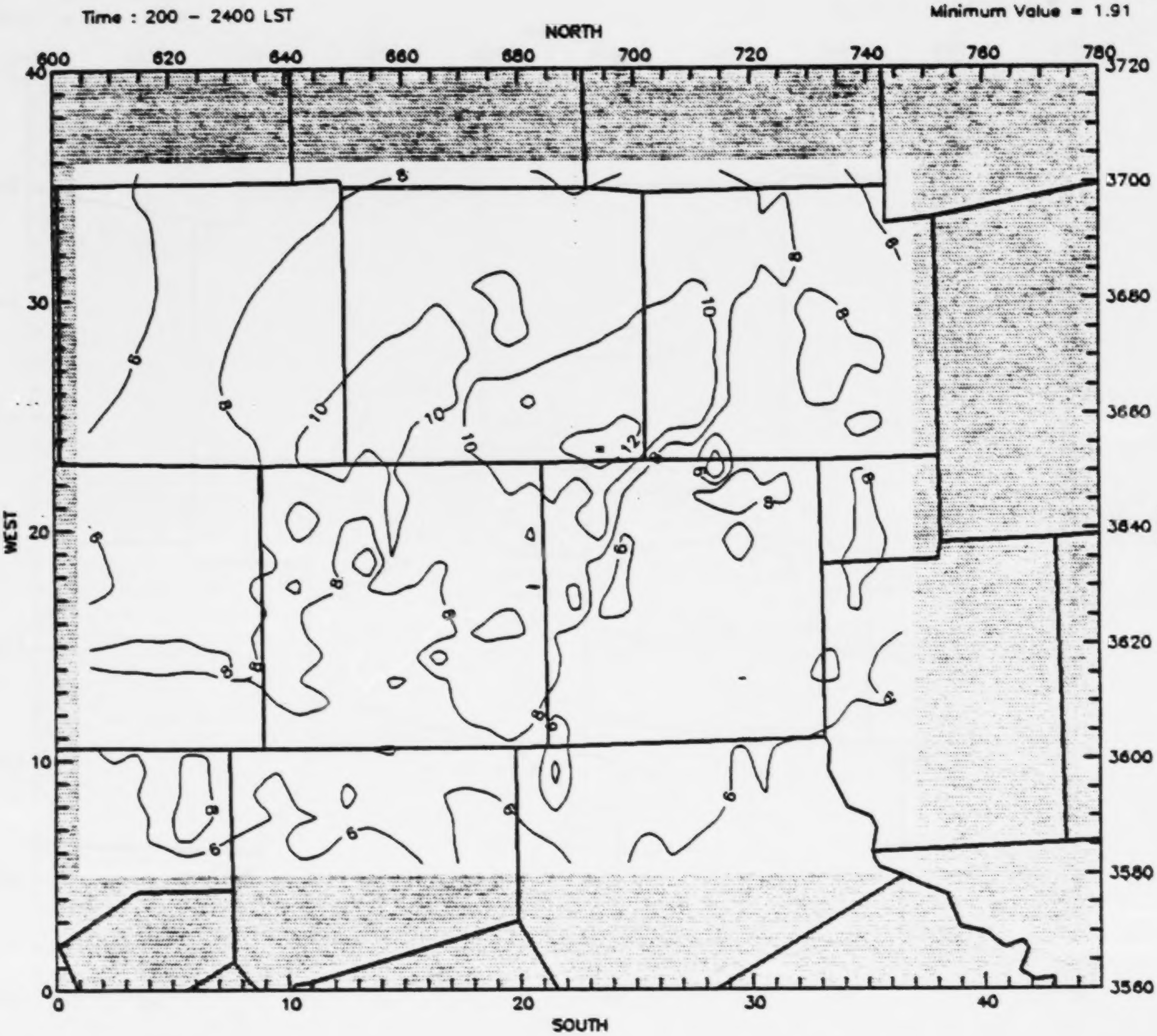
620
640
660
680
700
720
740
760
780
3720
3700
3680
3660
3640
3620
3600
3580
3560
0
10
20
30
40
6
8
10

FIGURE 3-2a. Predicted Daily Maximum Ozone Concentration (pphm) in Dallas-Fort Worth on 30 August 1985 for 1995 Scenario#1 Emission Scenario


Maximum Value = 13.33
Minimum Value = 1.91
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NORTH
SOUTH
WEST
EAST
600
620
640
660
680
700
720
740
760
780
3720
3700
3680
3660
3640
3620
3600
3580
3560
0
10
20
30
40
6
8
10
12

FIGURE 3-2b. Predicted Daily Maximum Ozone Concentration (pphm) in Dallas-Fort Worth on 31 August 1985 for 1995 Scenario#1 Emission Scenario

shown in Figure 3-3. There are regions of increases and decreases in the daily maximum ozone concentrations in response to the reductions of VOC and NO_x emissions. The areal extent of decreases in daily maximum ozone concentrations is larger than the region of increases. However, the increases occur at the location of the peak ozone concentration.

The disbenefits of controlling NO_x emissions in Dallas-Fort Worth in 1995 is further illustrated in the type B SIP control scenario #2 (Figure 3-4 and 3-5). The only difference between scenario #2 and scenario #1 is that scenario #2 has an additional 28 percent reduction in NO_x emissions. As seen in Figure 3-4a, the decrease in NO_x emissions causes the ozone peak to occur closer to the urban core. The additional NO_x emission reductions also cause the peak ozone concentration in scenario #2 to be higher than in scenario #1. In fact on 30 August the scenario #2 peak ozone concentration (12.8 pphm) is higher than the 1995 base case (11.6 pphm) and causes a violation of the ozone NAAQS.

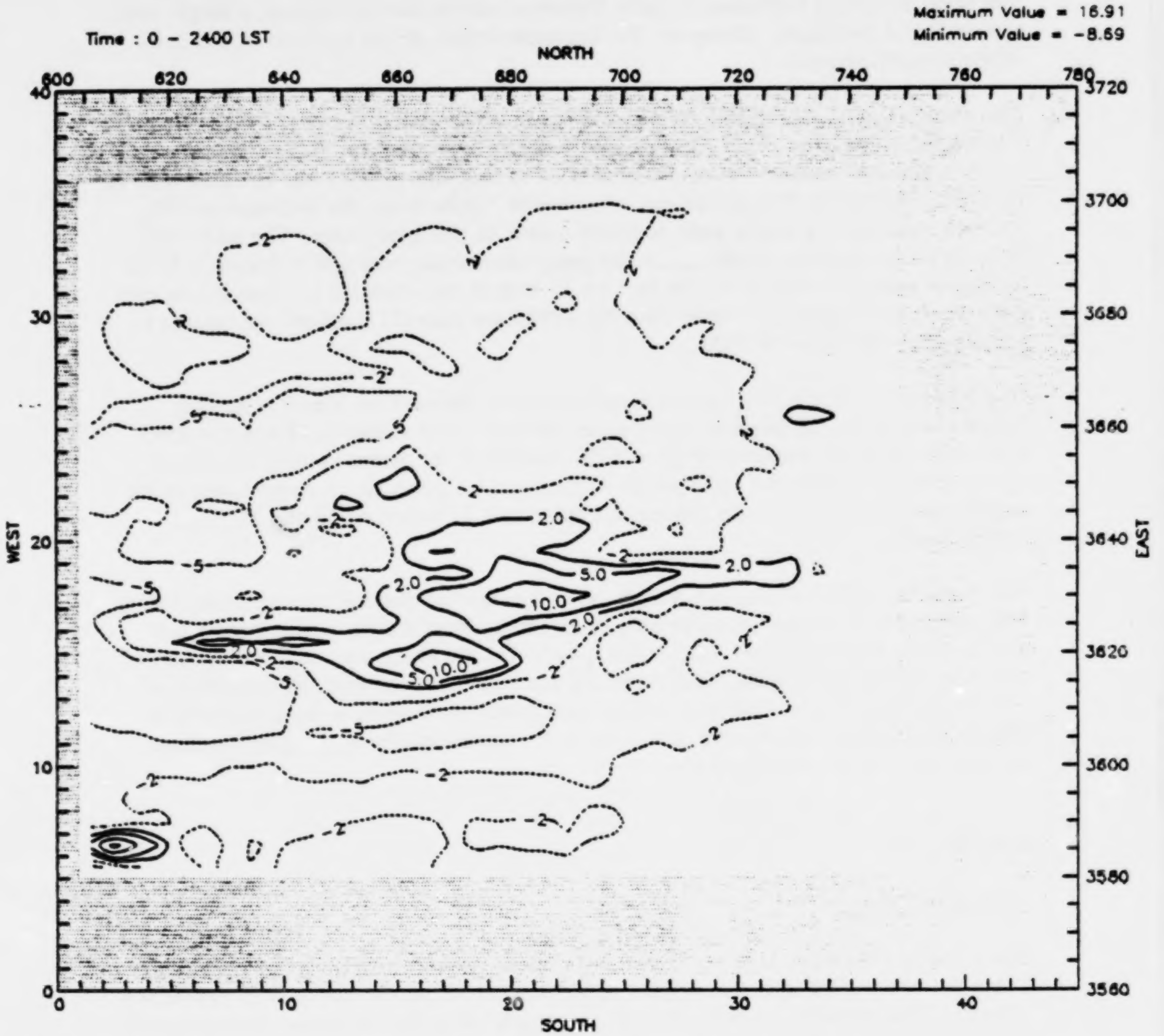
The disbenefits of the NO_x emission reductions in Dallas-Fort Worth is further emphasized in the DE plots of differences between 1995 scenario #2 and the 1995 base case emission scenarios (Figure 3-5). Maximum increases in daily maximum ozone concentrations, 5.9 pphm on 30 August and 6.1 pphm on 31 August, are much larger than the maximum decreases, 2.1 pphm and 2.7 pphm on 30 and 31 August, respectively.

The fact that 1995 Dallas-Fort Worth shows substantial disbenefits when controlling NO_x emissions is somewhat surprising since Dallas-Fort Worth is considerd a city with a fairly high measured VOC-to-NO_x ratio (11.8), which would indicate that NO_x controls may be beneficial. This modeling analysis demonstrates the necessity of examining NO_x controls for each region separately to determine their benefits or disbenefits rather than relying on a simplistic representation of a regions characteristic such as the measured VOC-to-NO_x ratio.

Atlanta

1995 Base Case

The Atlanta 1995 base case predicts a peak ozone concentration of 12.5 pphm (see Table 3-1 and Figure 3-6) that occurs approximately 20 km to the east of downtown Atlanta. The presence of several large power plants to the northwest and southeast of the city of Atlanta are clearly visible in the isopleth of daily maximum ozone concentrations (Figure 3-6). NO_x emissions from the power plants cause an initial supresion of the ozone concentrations at the location of the power plants followed by higher ozone concentrations further downwind to the east of the power plants.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Minimum Value = -8.69
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NORTH
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620
640
660
680
700
720
740
760
780
3720
3700
3680
3660
3640
3620
3600
3580
3560
EAST
WEST
40
30
20
10
0
0
10
20
30
40
SOUTH
-2
-.5
.5
2.0
5.0
10.0

FIGURE 3-3a. Differences in Daily Maximum Ozone Concentrations (ppb) between 1995 base case and 1995 scenario#1 emission scenarios (scenario#1 - base) in Dallas-Fort Worth on 30 August 1985.

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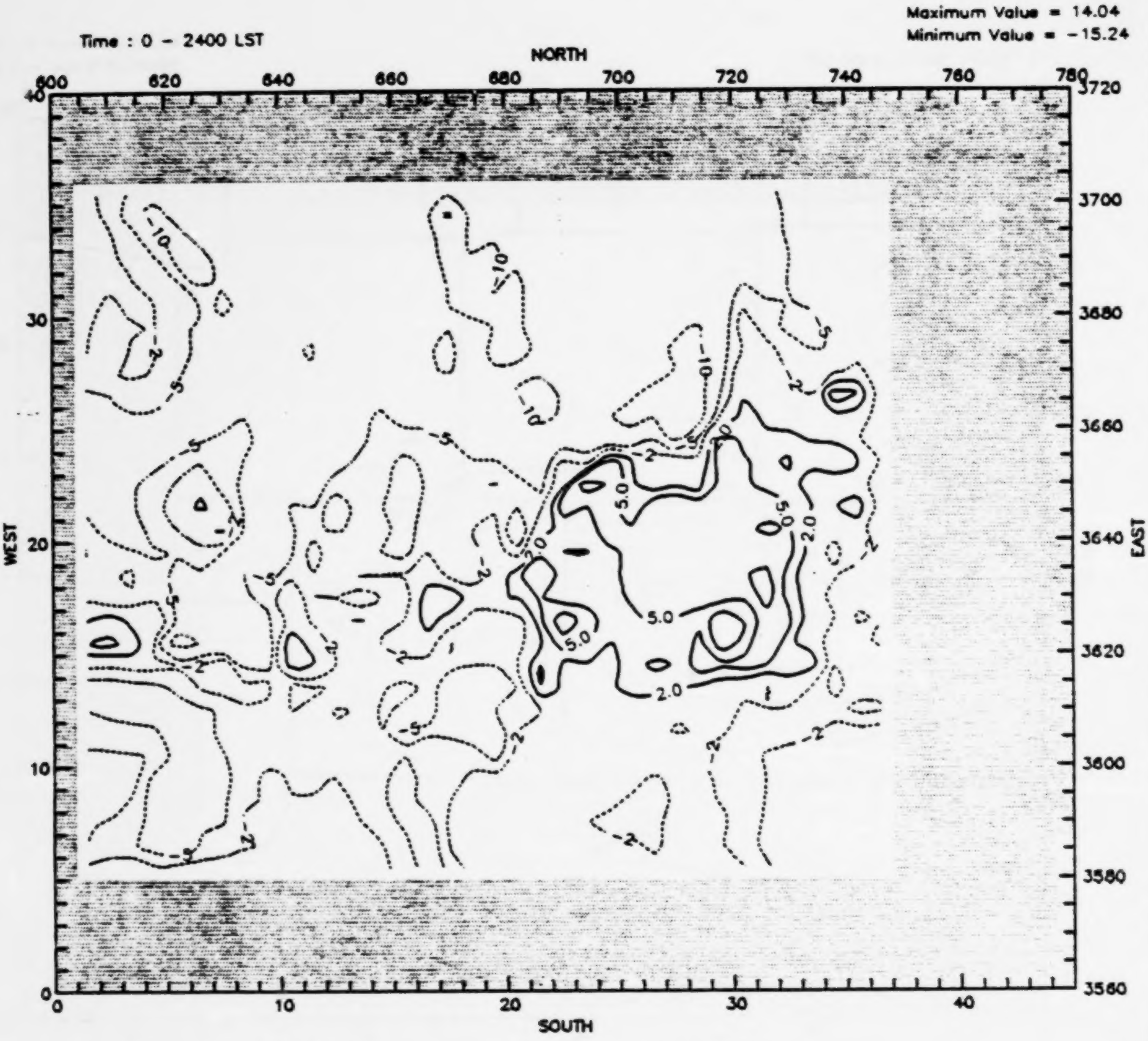
Maximum Value = 14.04
Minimum Value = -15.24
Time : 0 - 2400 LST
NORTH
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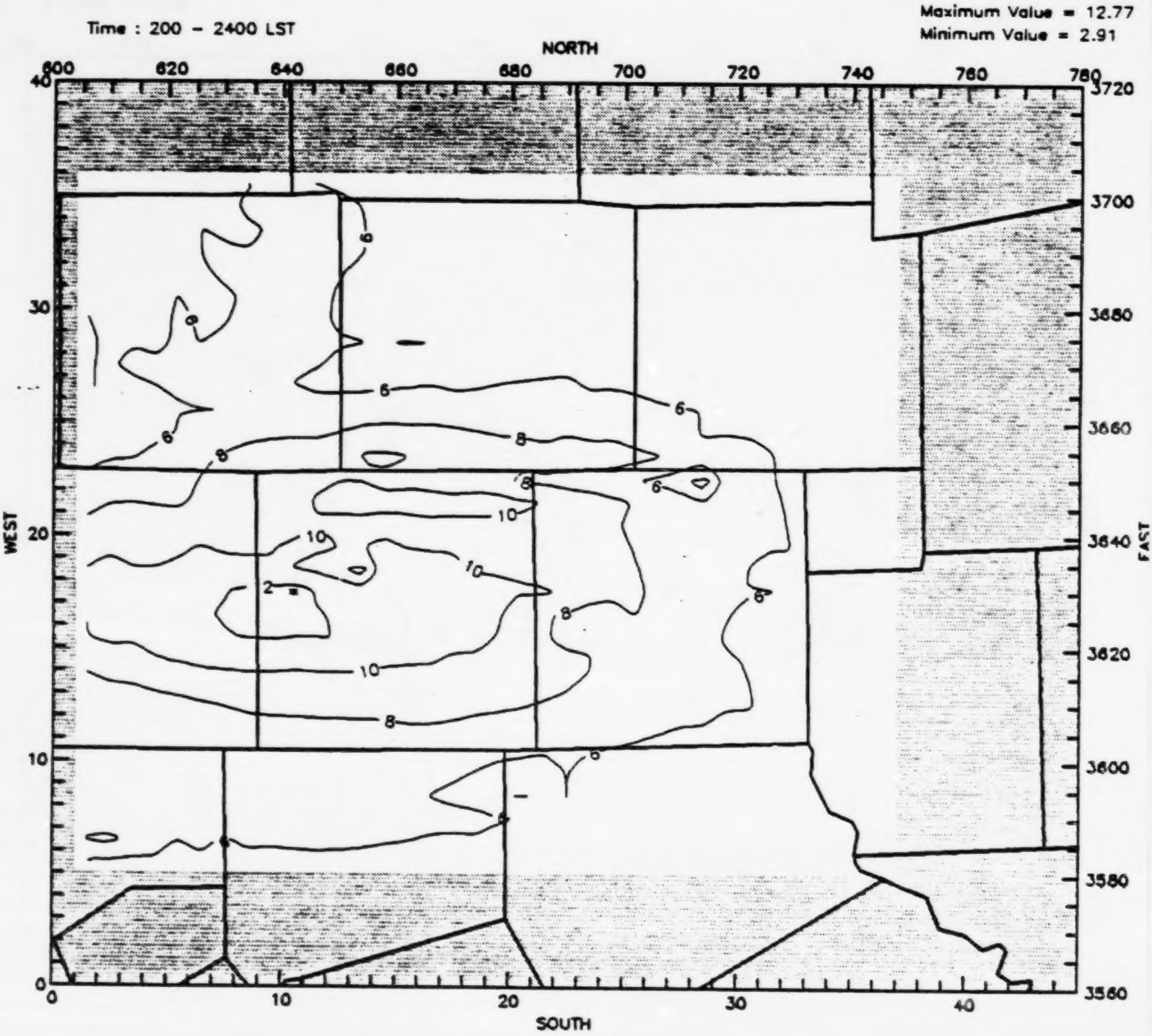
620
640
660
680
700
720
740
760
780
3720
3700
3680
3660
3640
3620
3600
3580
3560
EAST
40
30
20
10
0
WEST
0
10
20
30
40
SOUTH
-10
-5
-2
5.0
2.0

FIGURE 3-3b. Differences in Daily Maximum Ozone Concentrations (ppb) between 1995 base case and 1995 scenario#1 emission scenarios (scenario#1 - base) in Dallas-Fort Worth on 31 August 1985.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Minimum Value = 2.91
NORTH
SOUTH
WEST
EAST
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620
640
660
680
700
720
740
760
780
3720
3700
3680
3660
3640
3620
3600
3580
3560
0
10
20
30
40
6
8
10
12

FIGURE 3-4a. Predicted Daily Maximum Ozone Concentration (pphm) in Dallas-Fort Worth on 30 August 1985 for 1995 Scenario#2 Emission Scenario

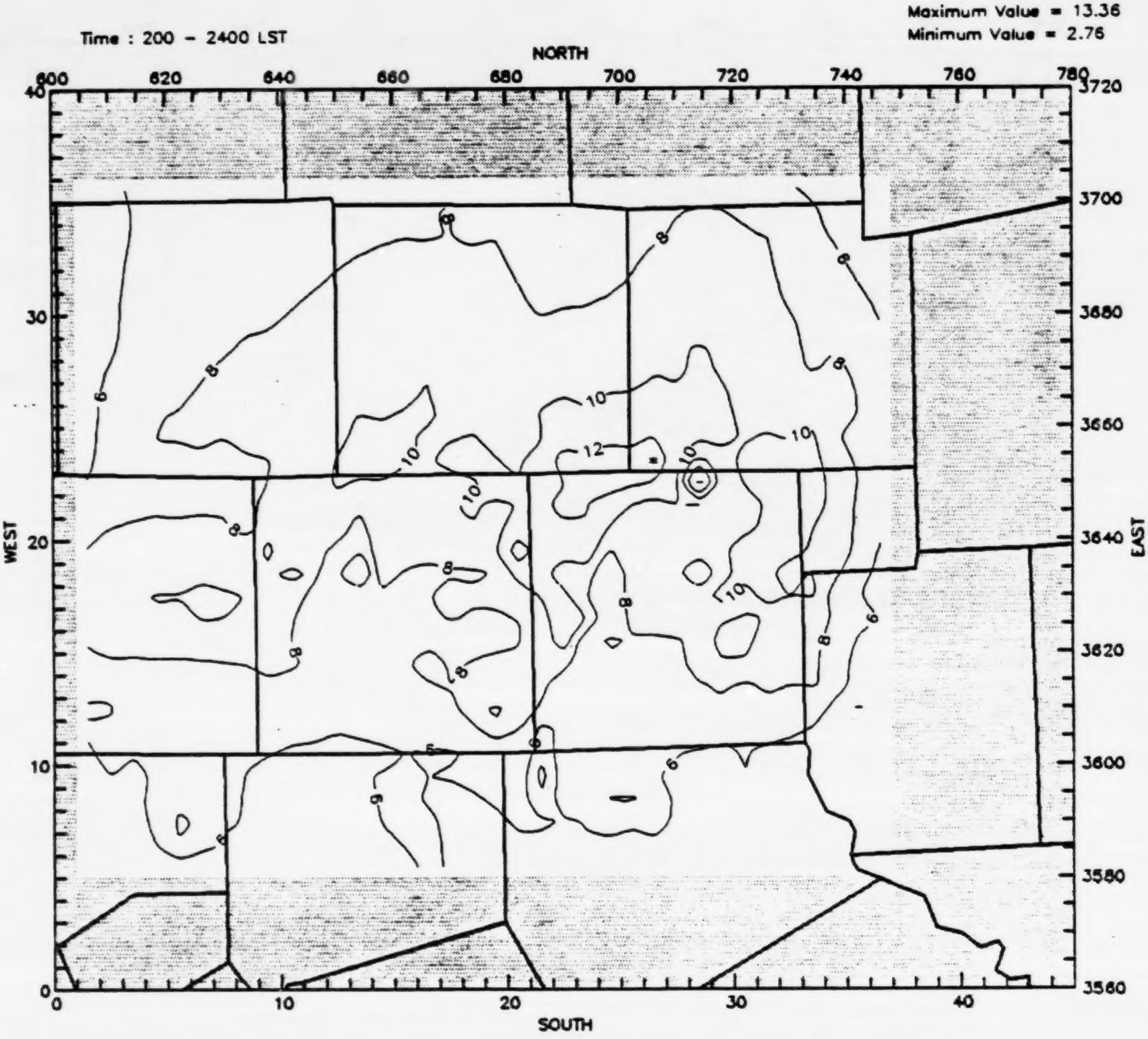

Maximum Value = 13.36
Minimum Value = 2.76
Time : 200 - 2400 LST
NORTH
SOUTH
WEST
EAST
600
620
640
660
680
700
720
740
760
780
3720
3700
3680
3660
3640
3620
3600
3580
3560
0
10
20
30
40
6
8
10
12

FIGURE 3-4b. Predicted Daily Maximum Ozone Concentration (pphm) in Dallas-Fort Worth on 31 August 1985 for 1995 Scenario#2 Emission Scenario

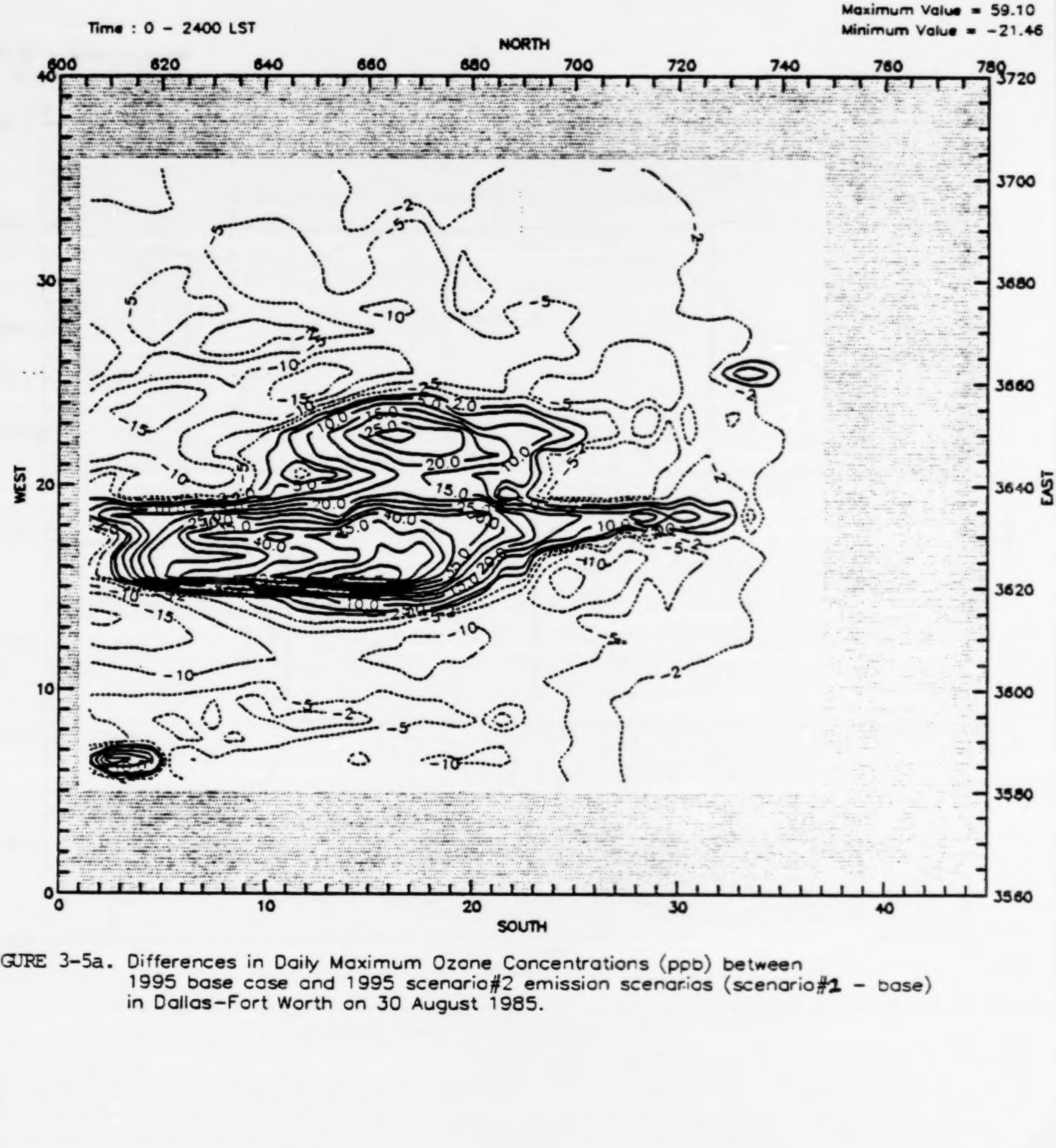
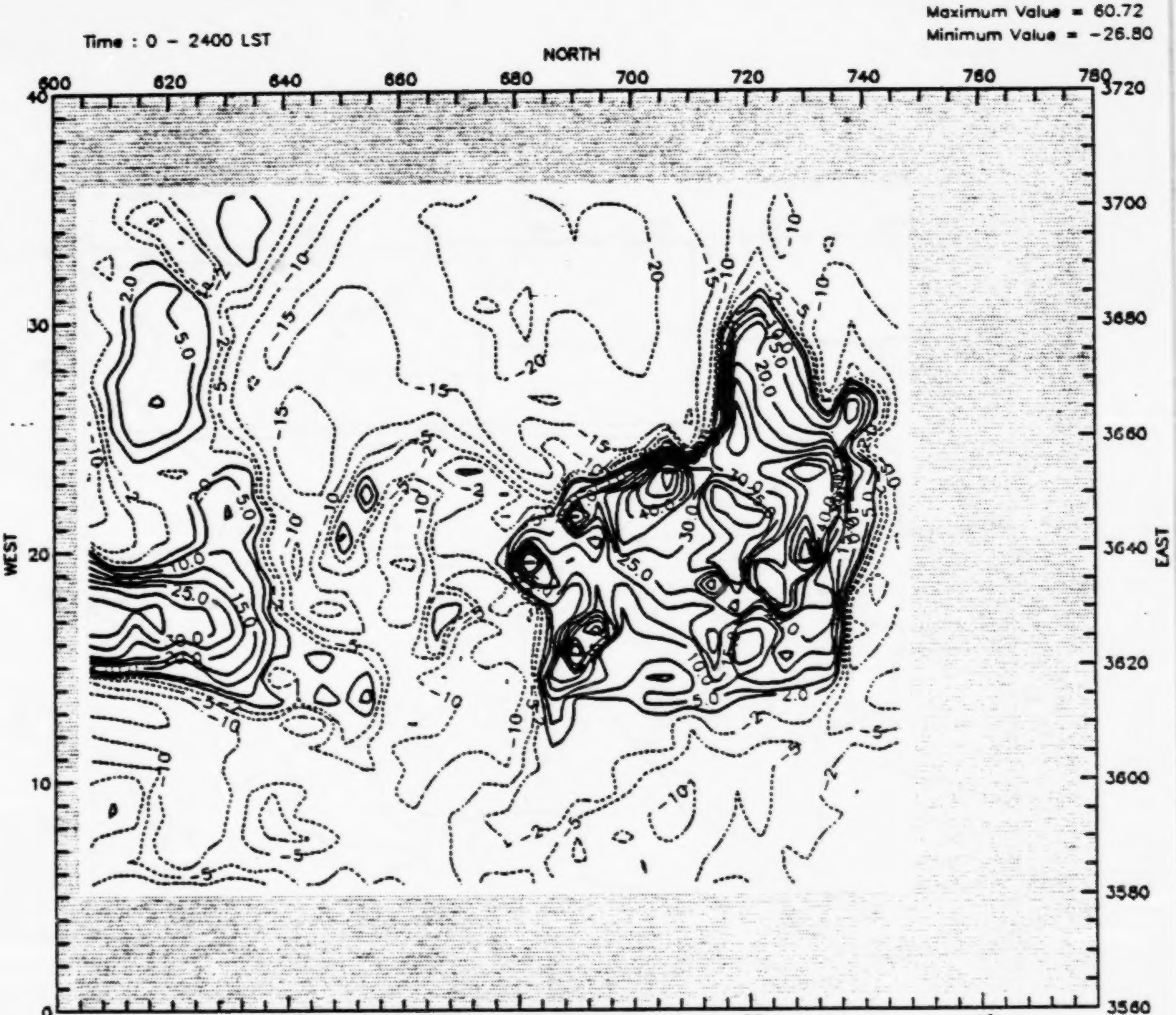

Maximum Value = 59.10
Minimum Value = -21.46
Time : 0 - 2400 LST
NORTH
SOUTH
WEST
EAST
600
620
640
660
680
700
720
740
760
780
3720
3700
3680
3660
3640
3620
3600
3580
3560
0
10
20
30
40
-2
-5
-10
-15
2.0
10.0
15.0
20.0
25.0
30.0
40.0

FIGURE 3-5a. Differences in Daily Maximum Ozone Concentrations (ppb) between 1995 base case and 1995 scenario#2 emission scenarios (scenario#1 - base) in Dallas-Fort Worth on 30 August 1985.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Minimum Value = -26.80
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SOUTH
WEST
EAST
600
620
640
660
680
700
720
740
760
780
3720
3700
3680
3660
3640
3620
3600
3580
3560
0
10
20
30
40

FIGURE 3-5b. Differences in Daily Maximum Ozone Concentrations (ppb) between 1995 base case and 1995 scenario#2 emission scenarios (scenario#1 - base) in Dallas-Fort Worth on 31 August 1985.

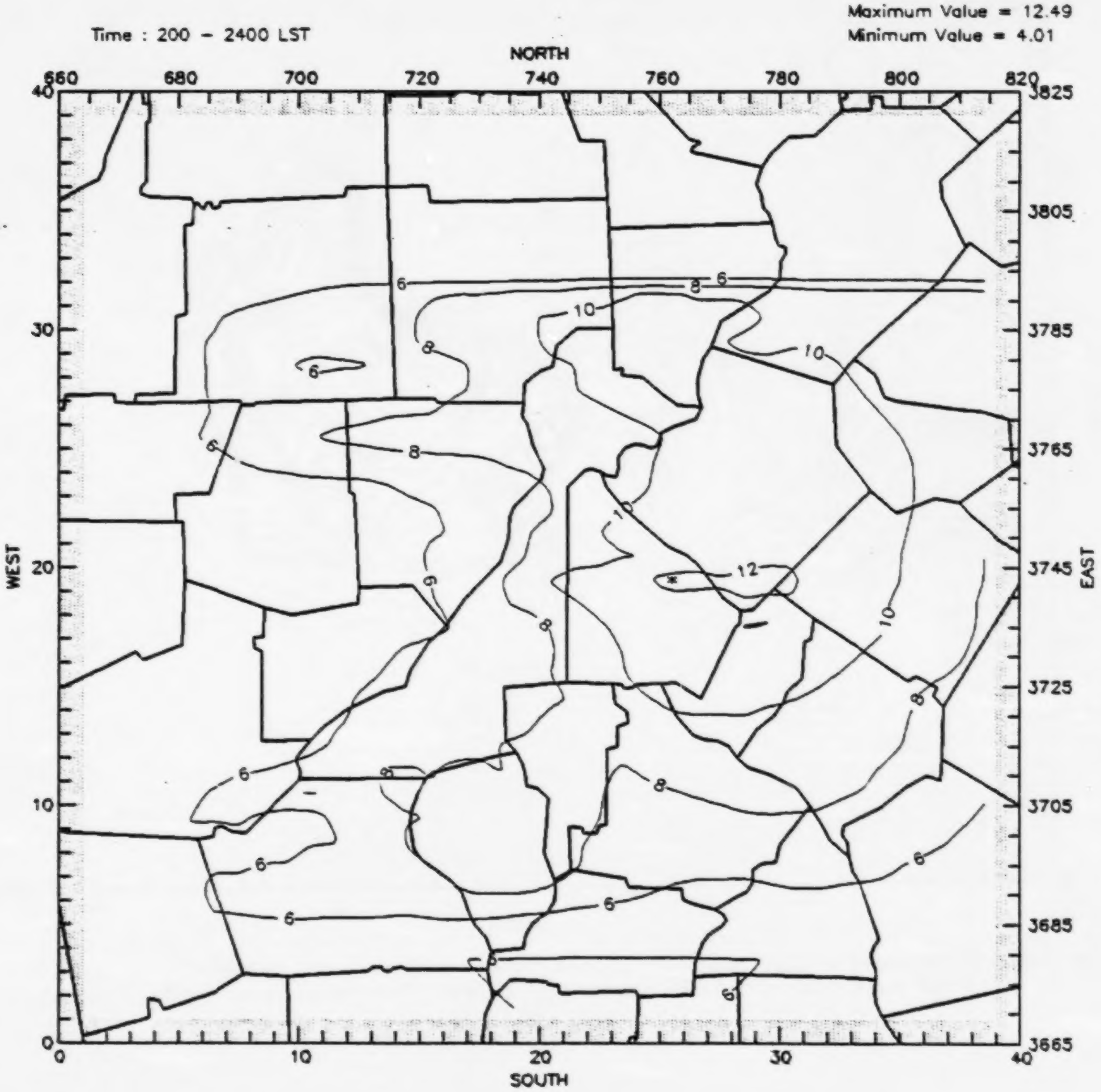

Time : 200 - 2400 LST
Maximum Value = 12.49
Minimum Value = 4.01
NORTH
SOUTH
WEST
EAST
660
680
700
720
740
760
780
800
820
3825
3805
3785
3765
3745
3725
3705
3685
3665
0
10
20
30
40
6
8
10
12

FIGURE 3-6. Predicted Daily Maximum Ozone Concentration (pphm) in Atlanta on 4 June 1984 for 1995 Base Case Emission Scenario

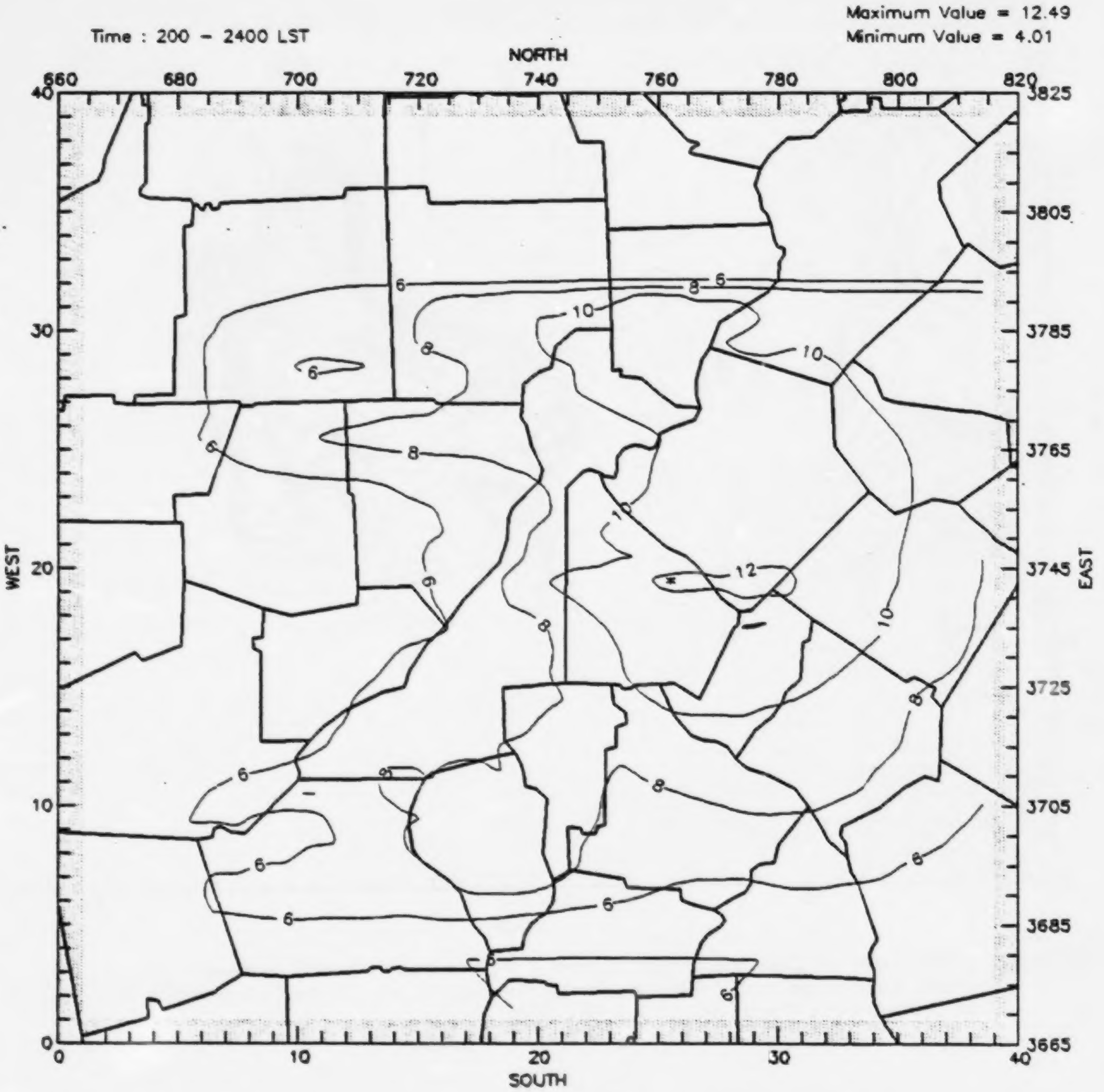

Time : 200 – 2400 LST
Maximum Value = 12.49
Minimum Value = 4.01
NORTH
660
680
700
720
740
760
780
800
820
3825
3805
3785
3765
3745
3725
3705
3685
3665
EAST
WEST
40
30
20
10
0
0
10
20
30
40
SOUTH
6
8
10
12

FIGURE 3-6. Predicted Daily Maximum Ozone Concentration (pphm) in Atlanta on 4 June 1984 for 1995 Base Case Emission Scenario

Type A SIP Control Strategies

A reduction of anthropogenic VOC emissions of 30, 60, and 90 percent from the Atlanta 1995 base case results in a decrease of the peak ozone concentration of 4.8, 11.2, and 15.2 percent, respectively (Table 3-1 and 3-2). Note that the type A VOC emission reductions for Dallas-Fort Worth are over twice as effective for reducing the peak ozone concentration than in Atlanta. This difference is because of the higher VOC-to-NO_x ratio in the Atlanta 1995 base case anthropogenic plus biogenic emission inventory (11.3) than seen for Dallas-Fort Worth (5.7).

Type B SIP Control Strategies

As seen in Table 3-2, the Atlanta 1995 type B SIP control strategies reduce the peak ozone concentration by 13.6 and 9.6 percent for, respectively, scenario #1 (18 percent VOC and 49 percent NO_x emission reduction and scenario #2 (18 percent VOC and 32 percent NO_x emission reduction). The isopleths of predicted daily maximum ozone concentrations for the two type B SIP control strategies and differences in daily maximum ozone concentrations between the two type B SIP control scenarios and the base case are given in Figures 3-7 through 3-10. Based on the type A SIP control strategies for Atlanta it is estimated that the 18 percent reduction in VOC emissions alone would result in an about a three percent reduction in the peak ozone concentration. Thus it appears that reducing NO_x emissions in Atlanta has a beneficial effect on reducing ozone concentrations. As seen in the DE plots (Figure 3-8 and 3-10), the only region where the NO_x emission controls results in increases in the daily maximum ozone concentrations is in the vicinity of the power plants.

St. Louis

1995 Base Case

Isopleths of daily maximum ozone concentrations for the St. Louis 1995 base case are given in Figure 3-11. The predicted peak ozone concentration for the St. Louis 1995 base case is 14.5 pphm and occurs in north St. Louis. Based on the current policy on emission controls it is estimated that the peak ozone concentration in 1976 (24.4 pphm) will be reduced by over 40 percent by 1995 (Table 3-1). The VOC-to-NO_x ratio in the St. Louis 1995 anthropoegnic emission inventory (3.7) is almost three times the value in the 1976 inventory (1.3). This is because of substantial reductions in elevated NO_x emissions and the inclusion of many VOC sources in the 1995 inventory (running losses, previously uninventoried sources, etc.) that were not in the 1976 inventory.

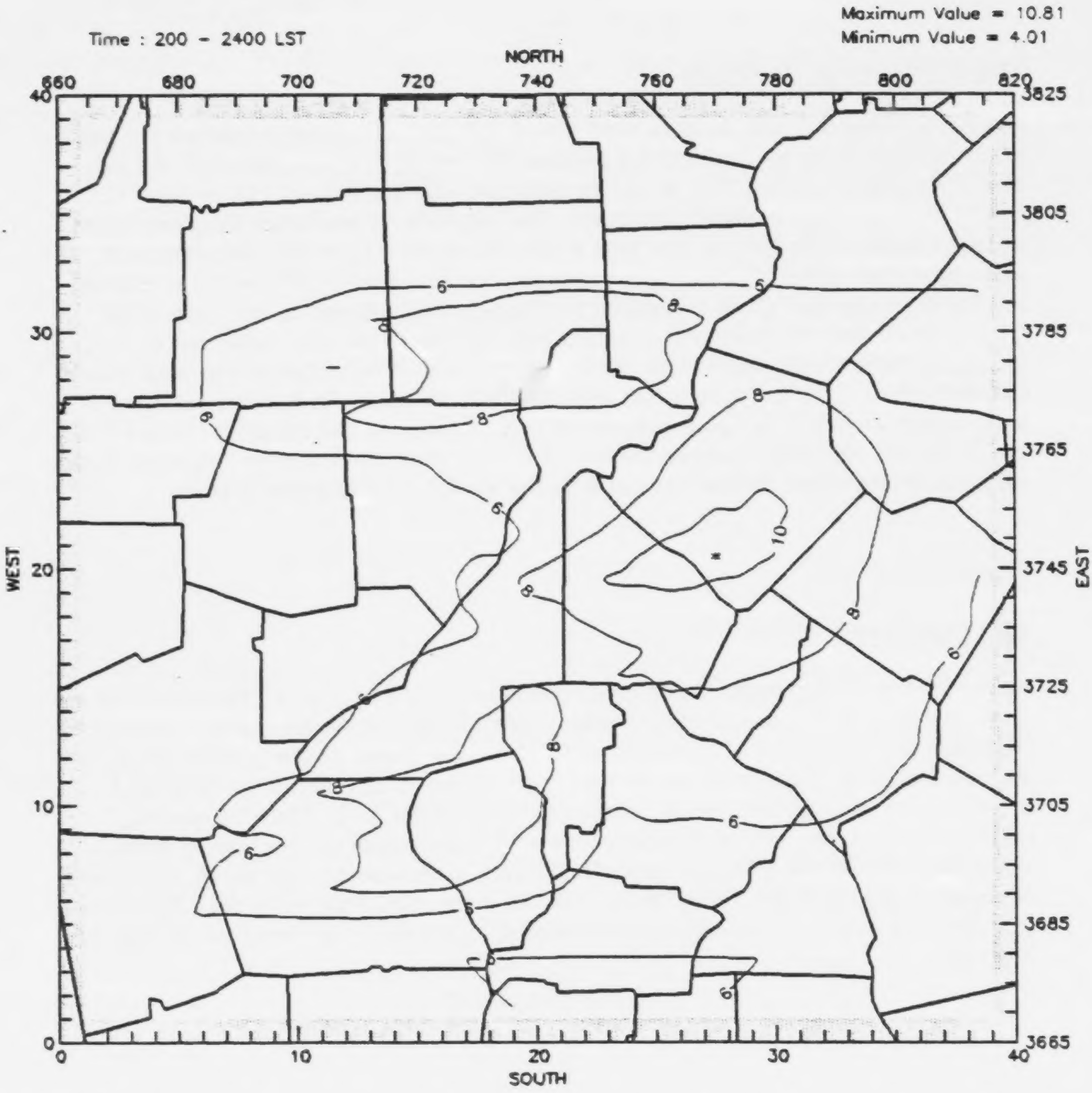
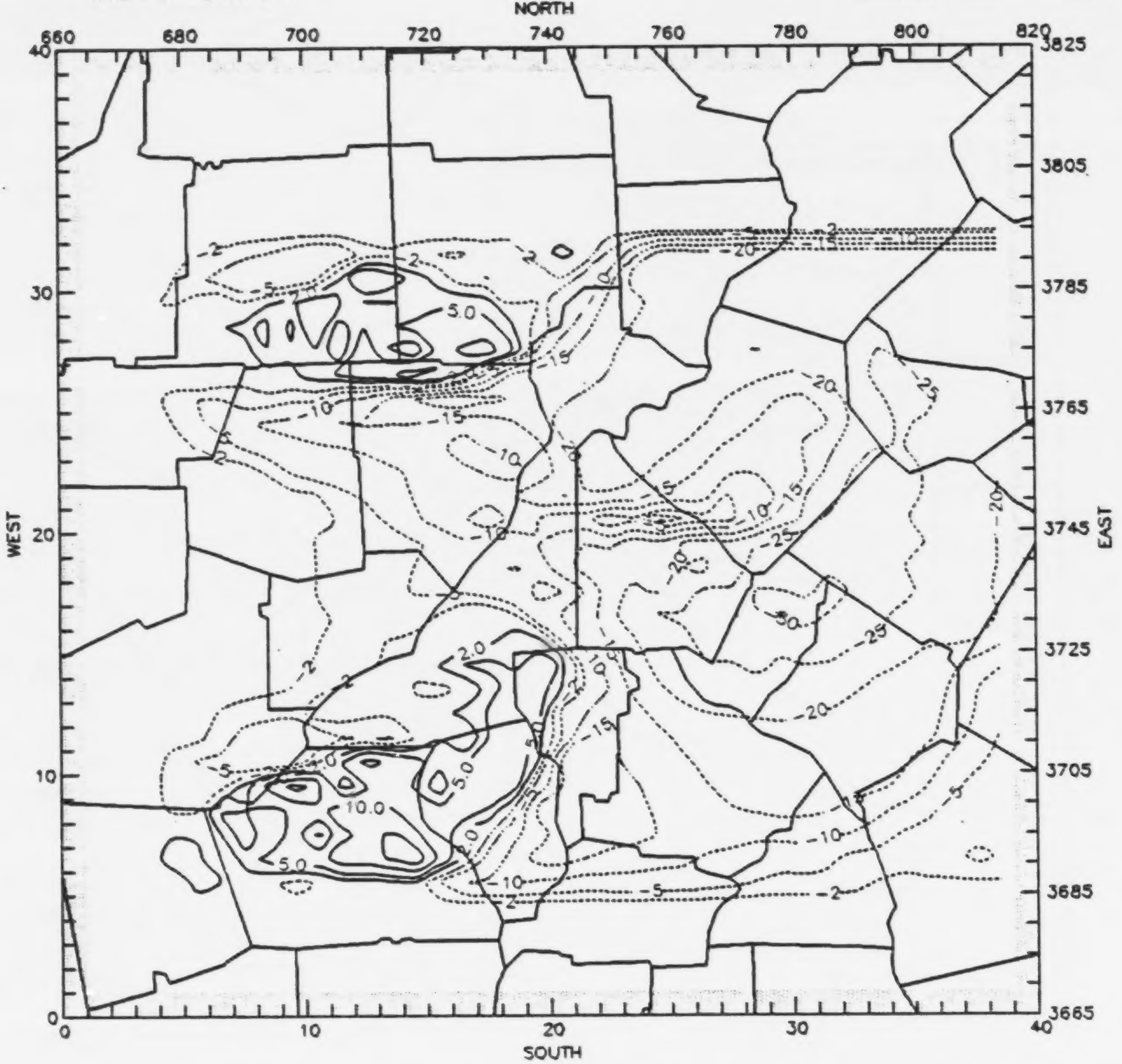

Maximum Value = 10.81
Minimum Value = 4.01
Time : 200 - 2400 LST
NORTH
660
680
700
720
740
760
780
800
820
3825
3805
3785
3765
3745
3725
3705
3685
3665
EAST
40
30
20
10
0
WEST
0
10
20
30
40
SOUTH
6
8
10

FIGURE 3-7. Predicted Daily Maximum Ozone Concentration (pphm) in Atlanta on 4 June 1984 for 1995 Scenario#1 Emission Scenario

Time : 0 – 2400 LST

Maximum Value = 18.56
Minimum Value = −31.08


NORTH
660
680
700
720
740
760
780
800
820
3825
3805
3785
3765
3745
3725
3705
3685
3665
EAST
WEST
40
30
20
10
0
SOUTH
0
10
20
30
40
-2
-5
5.0
10.0
2.0
-10
-15
-20
-25
-30

GURE 3-8. Differences in Daily Maximum Ozone Concentrations (ppb) between 1995 Base Case and 1995 Scenario#1 Emission Scenarios

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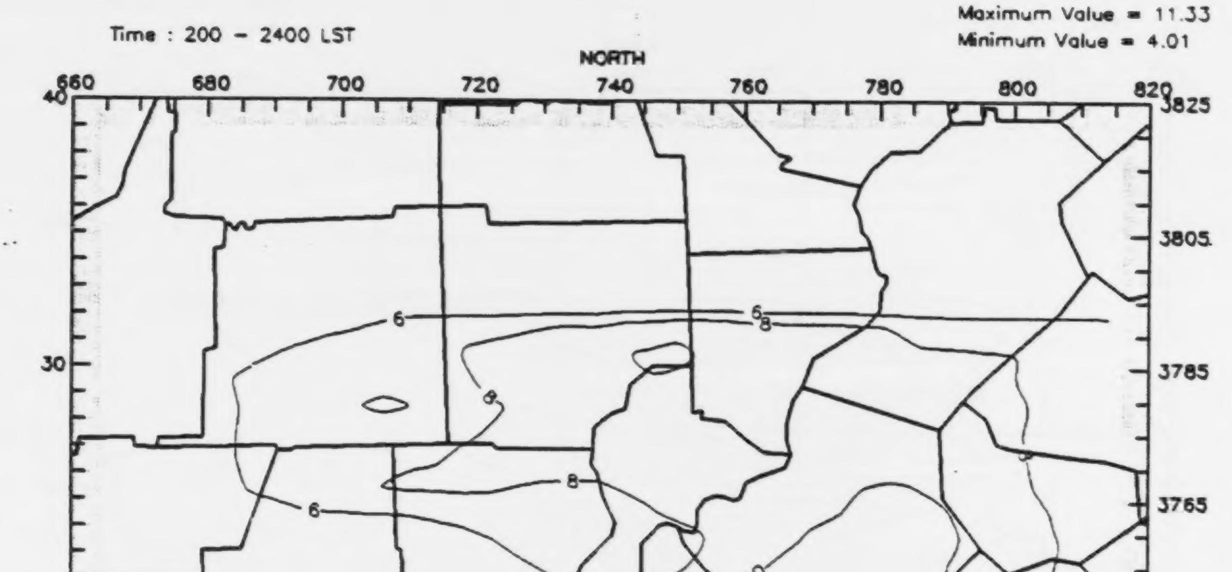
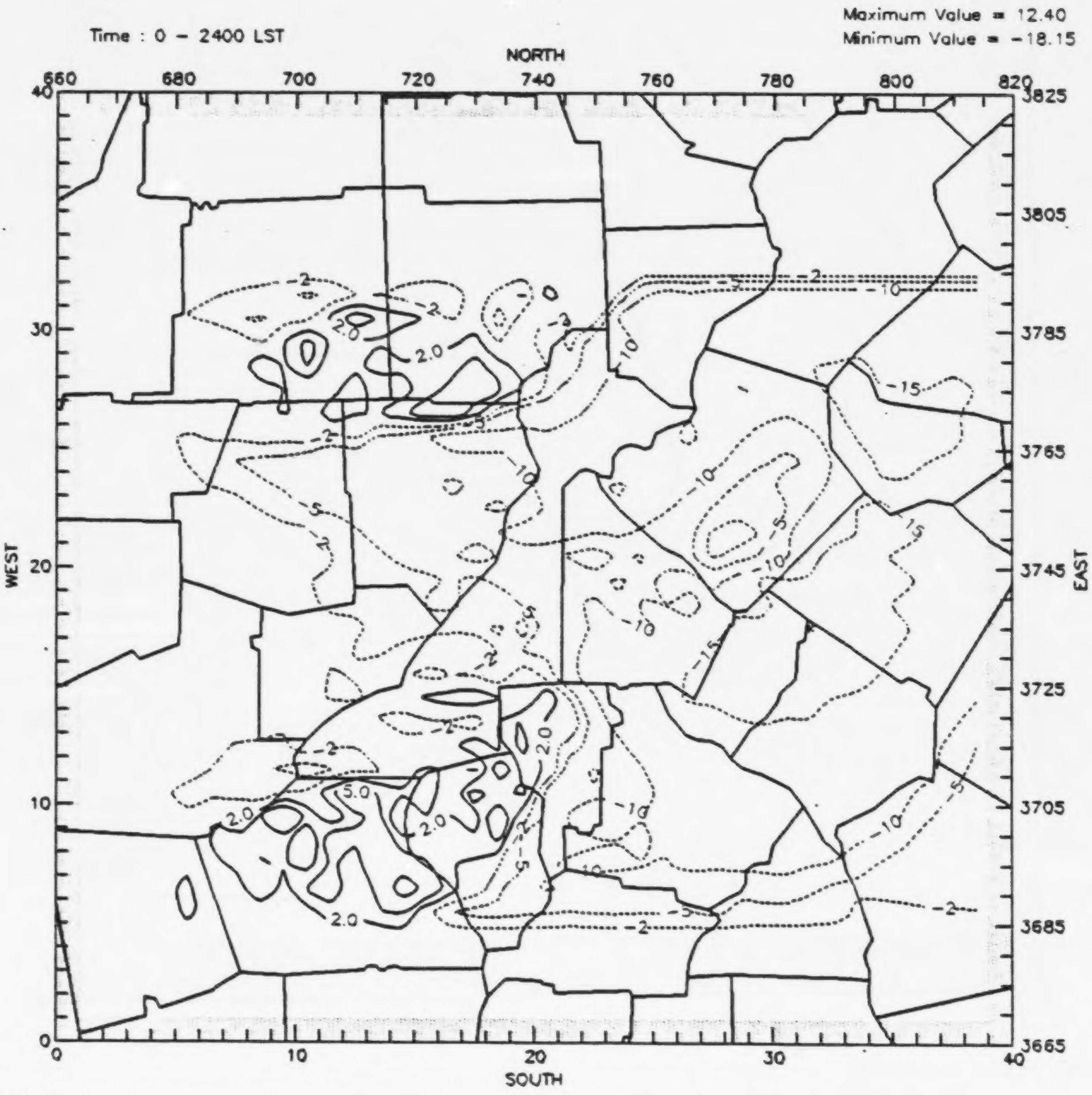

Time : 200 – 2400 LST
Maximum Value = 11.33
Minimum Value = 4.01
NORTH
SOUTH
WEST
EAST
660
680
700
720
740
760
780
800
820
3825
3805
3785
3765
3745
3725
3705
3685
3665
0
10
20
30
40
6
8
10

FIGURE 3-9. Predicted Daily Maximum Ozone Concentration (pphm) in Atlanta on 4 June 1984 for 1995 Scenario#2 Emission Scenario


Time : 0 – 2400 LST
Maximum Value = 12.40
Minimum Value = −18.15
NORTH
SOUTH
WEST
EAST
660
680
700
720
740
760
780
800
820
3825
3805
3785
3765
3745
3725
3705
3685
3665
0
10
20
30
40
-2
2.0
5.0
-5
-10
-15

GURE 3-10. Differences in Daily Maximum Ozone Concentrations (ppb) between 1995 Base Case and 1995 Scenario#2 Emission Scenarios (Scenario#2 – Base) in Atlanta on 4 June 1984

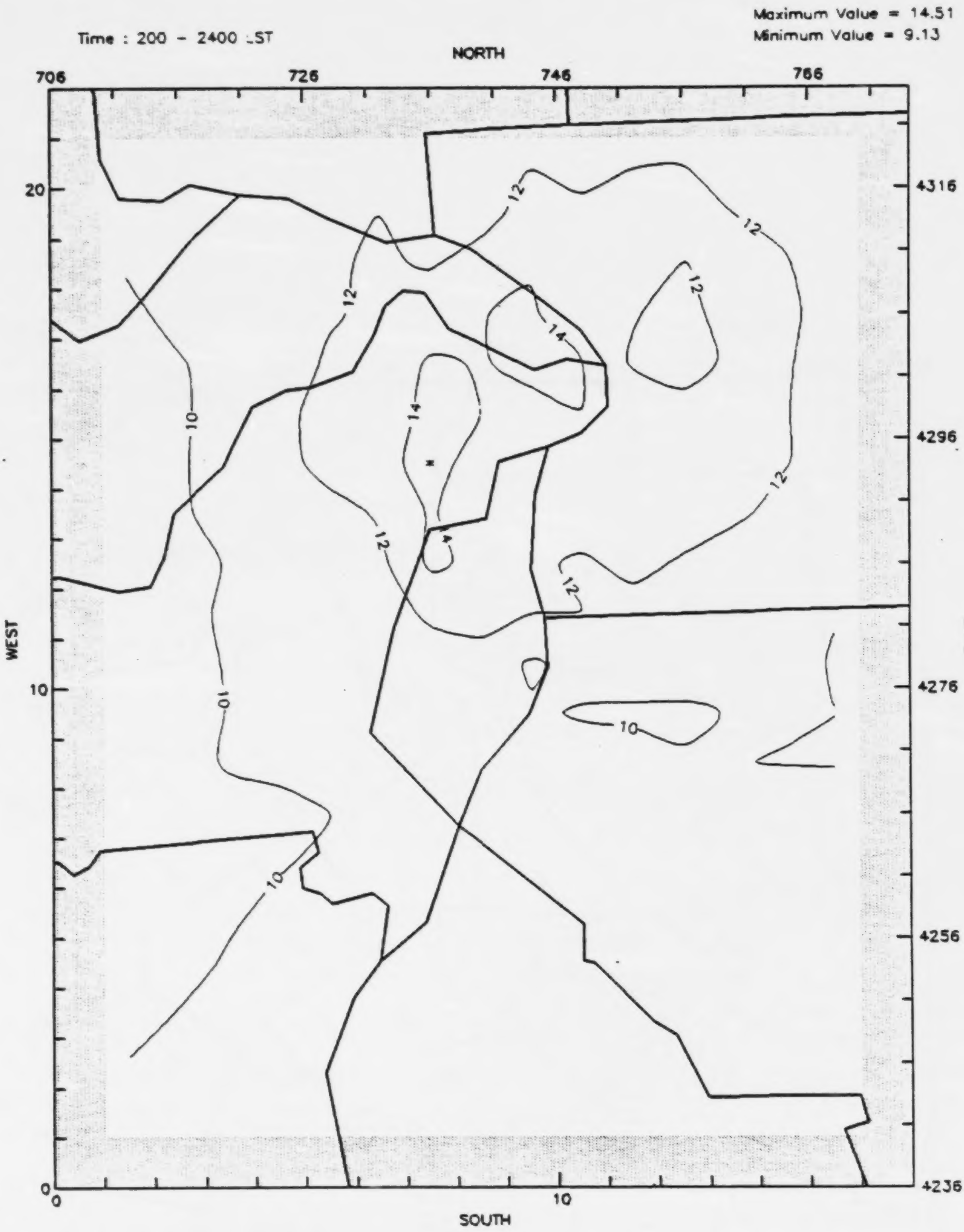

Maximum Value = 14.51
Minimum Value = 9.13
Time : 200 - 2400 LST
NORTH
706
726
746
766
20
10
0
4316
4296
4276
4256
4236
WEST
EAST
SOUTH
0
10
12
12
12
12
12
12
14
14
14
10
10
10
10

FIGURE 3-11. Predicted Daily Maximum Ozone Concentration (pphm) in St. Louis on 13 July 1976 for 1995 Base Case Emission Scenario

Type B SIP Control Strategies

Isopleths of daily maximum ozone concentrations for St. Louis SIP scenario #1 and differences in daily maximum ozone between scenario #1 and the base case are given in Figures 3-12 and 3-13, respectively. Similar plots for the 1995 SIP scenario #2 are given in Figures 3-14 and 3-15. The emission reductions in scenario #1 (24 percent reduction in VOC emissions and 26 percent reduction in NO_x emissions) results in a 8.3 percent reduction in the peak ozone concentration (13.3 pphm) from the base case (14.5 pphm). Scenario #2 differs from scenario #1 in that there is an additional 12 percent reduction in NO_x emissions. This additional reduction in NO_x emissions results in an increase in the peak ozone concenrations of from 13.3 pphm (scenario #1) to 13.4 pphm (scenario #2).

Discussion

Despite the fact that the three cities studied have similar measured 1985 median VOC-to-NO_x ratios (9.6 St. Louis, 10.4 Atlanta, and 11.8 Dallas-Fort Worth), the effects of VOC and NO_x emission reductions on the peak ozone concentration are quite different. Reducing NO_x emissions in 1995 Dallas-Fort Worth and St. Louis results in increases in the peak ozone concentration, whereas, reducing NO_x emissions in 1995 Atlanta results in a decrease in the peak ozone concentration. Reducing VOC emissions always results in a reduction in the peak ozone concentration, although the VOC reductions in Dallas-Fort Worth are over twice as effective at reducing the peak ozone concenration than in Atlanta.

1995 ALTERNATIVE FUEL SCENARIOS

The results for the three 1995 alternative fuel scenarios are presented for Dallas-Fort Worth, St. Louis, and Philadelphia. As noted in Section 2, the three fuel scenarios (new gas regs, M100, CNG) were based on a 20 mph average speed assumption, which is somewhat lower than speeds used to create the 1985 NAPAP inventory that was used as a basis for developing the 1995 base case emissions estimates. Care should be exercised when comparing results between the 1995 base case and fuel strategies, since exhaust emissions factors increase with decreasing vehicle speed. The differences in peak ozone between the 1995 base case and fuel strategies than reported in Tables 3-3a,b might be larger if all 1995 scenarios utilized identical speed assumptions.

Dallas-Fort Worth

New Regulations for Gas Vehicles

Isopleths of the predicted daily maximum ozone concentrations for the 1995 new reg gas scenario is given in Figure 3-16. The peak ozone concentration for the 1995 new

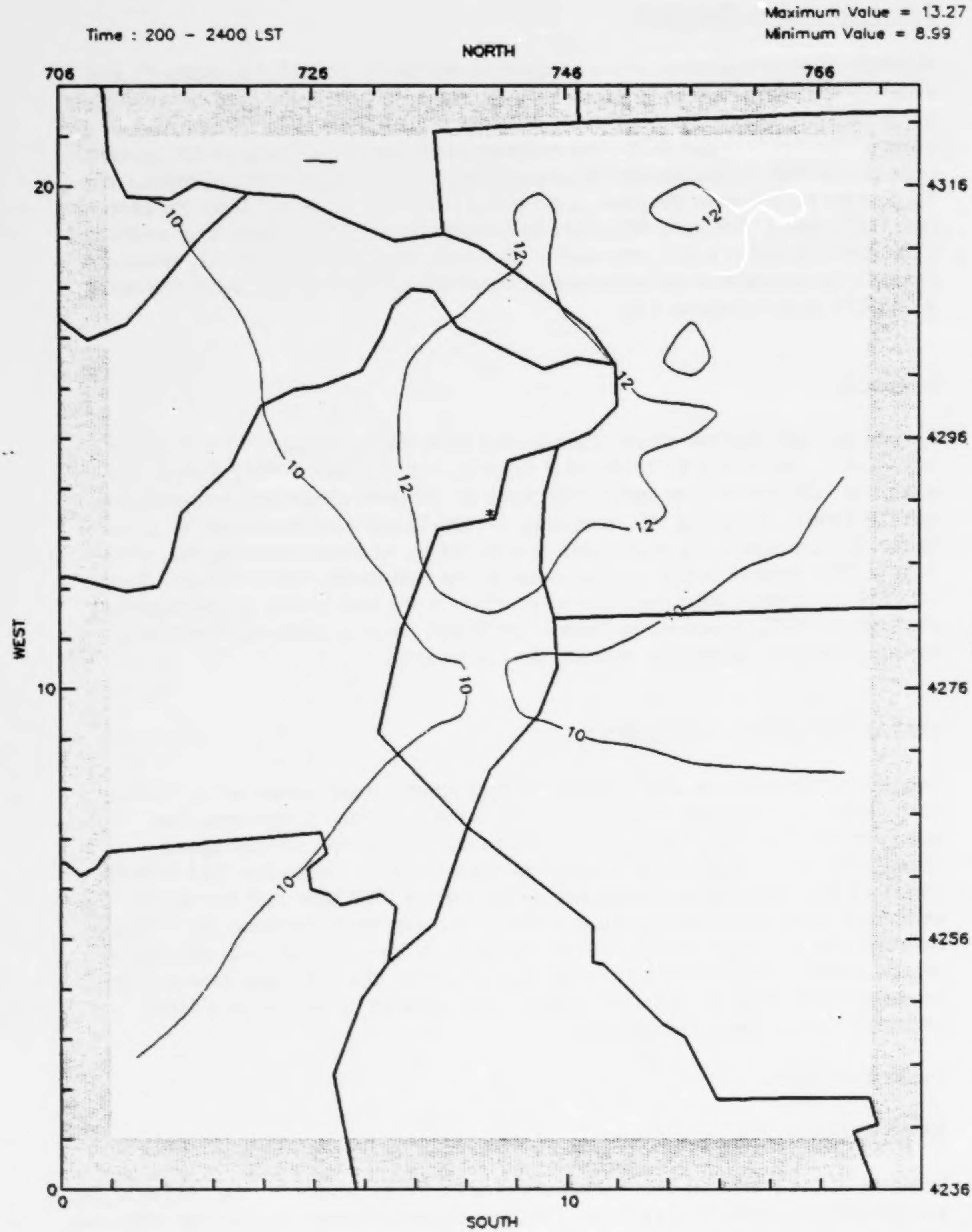
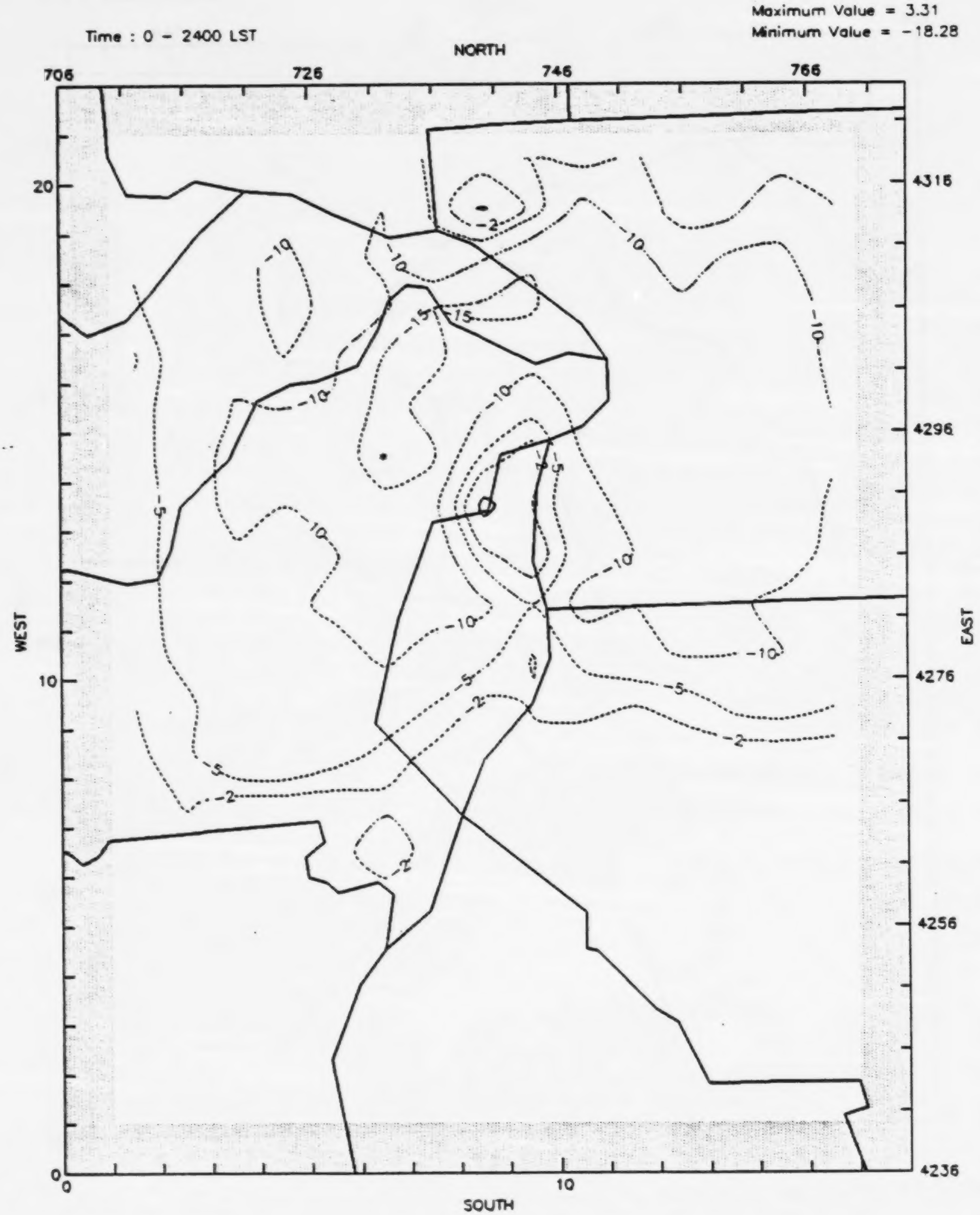

Maximum Value = 13.27
Minimum Value = 8.99
Time : 200 - 2400 LST
NORTH
706
726
746
766
20
10
0
WEST
EAST
4316
4296
4276
4256
4236
0
10
SOUTH
10
12
12
12
12
10
12
10
10
10
10

FIGURE 3-12. Predicted Daily Maximum Ozone Concentration (pphm) in St. Louis on 13 July 1976 for 1995 Scenario#1 Emission Scenario


Maximum Value = 3.31
Minimum Value = -18.28
Time : 0 - 2400 LST
NORTH
706
726
746
766
20
10
0
0
10
WEST
EAST
SOUTH
4316
4296
4276
4256
4236
-2
-10
-10
-10
-15
-15
-10
-10
-10
-5
-5
-10
-10
-10
-10
-5
-2
-5
-2
-5
-2
-2

GURE 3-13. Differences in Daily Maximum Ozone Concentrations (ppb) between 1995 base case and 1995 Scenario#1 emission scenarios (scenario#1 - base) in St. Louis on 13 July 1976

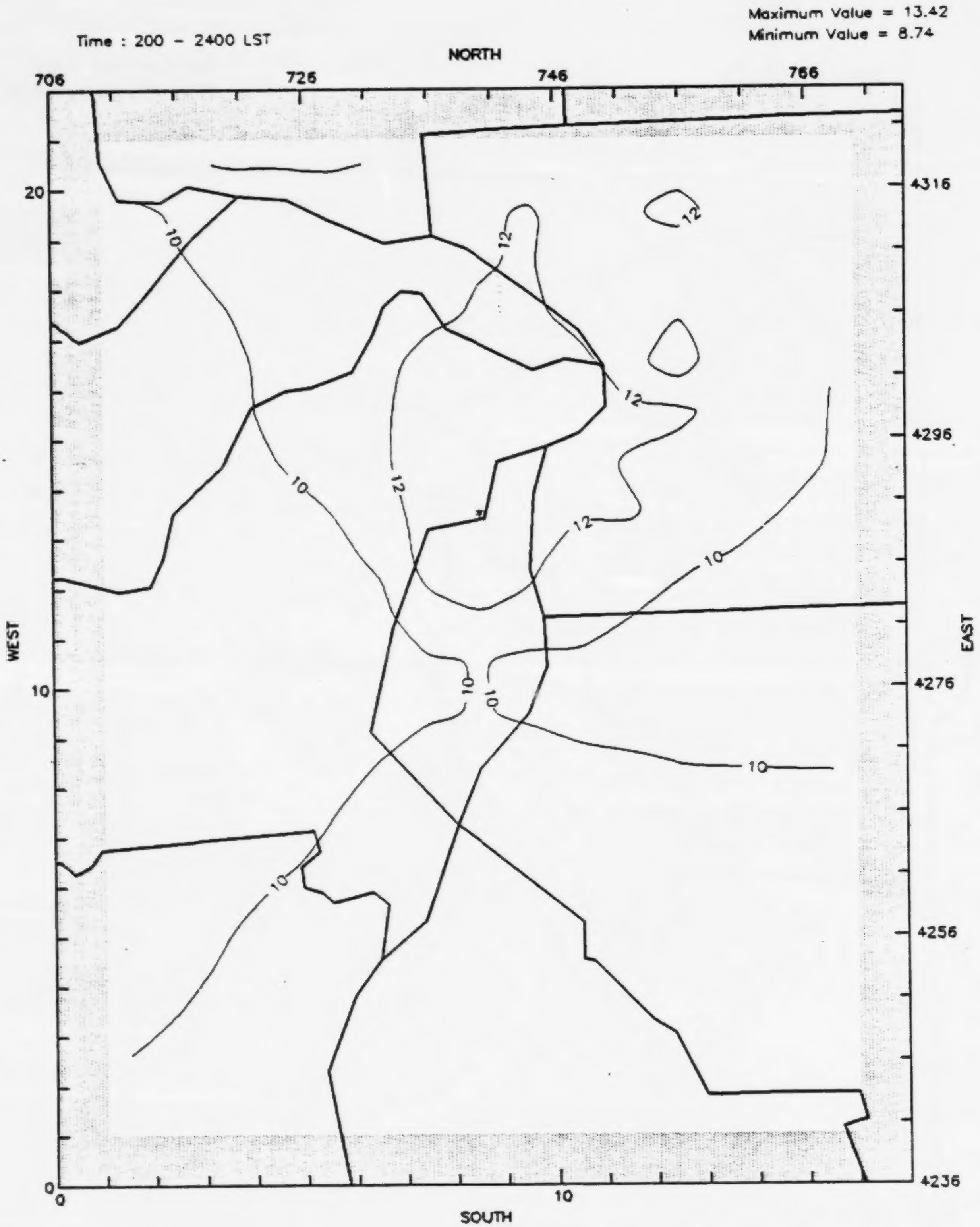
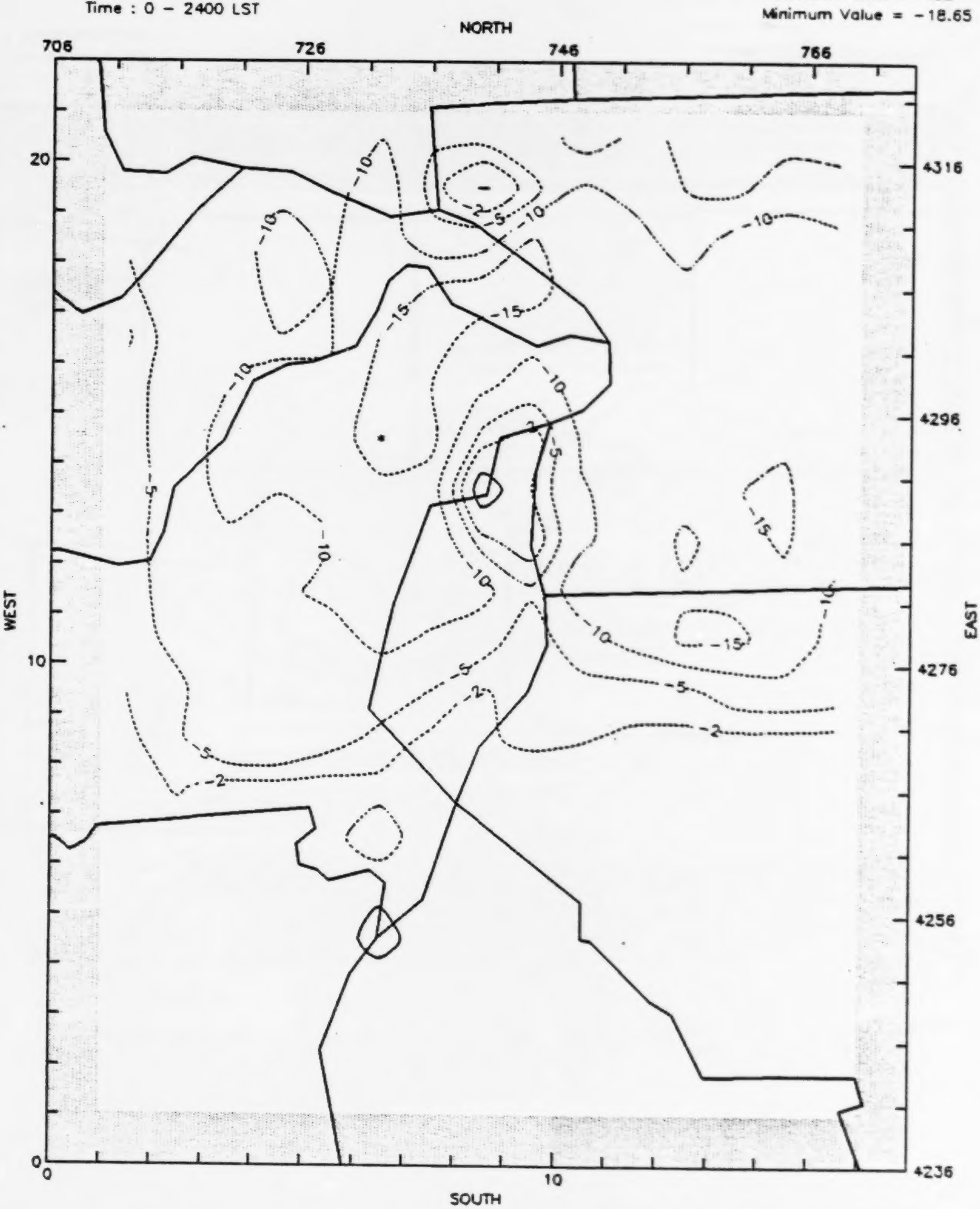

Maximum Value = 13.42
Minimum Value = 8.74
Time : 200 - 2400 LST
NORTH
706
726
746
766
20
10
0
WEST
4316
4296
4276
4256
4236
EAST
0
10
SOUTH
10
12
12
12
12
12
10
10
10
10
10
10
10

FIGURE 3-14. Predicted Daily Maximum Ozone Concentration (pphm) in St. Louis on 13 July 1976 for 1995 Scenario#2 Emission Scenario


Time : 0 – 2400 LST
Maximum Value = 4.82
Minimum Value = –18.65
NORTH
706
726
746
766
20
10
0
WEST
EAST
SOUTH
4316
4296
4276
4256
4236
-10
-2
-5
-15
-5
-2

RE 3-15. Differences in Daily Maximum Ozone Concentrations (ppb) between 1995 base case and 1995 Scenario#2 emission scenarios (scenario#2 – base)

52

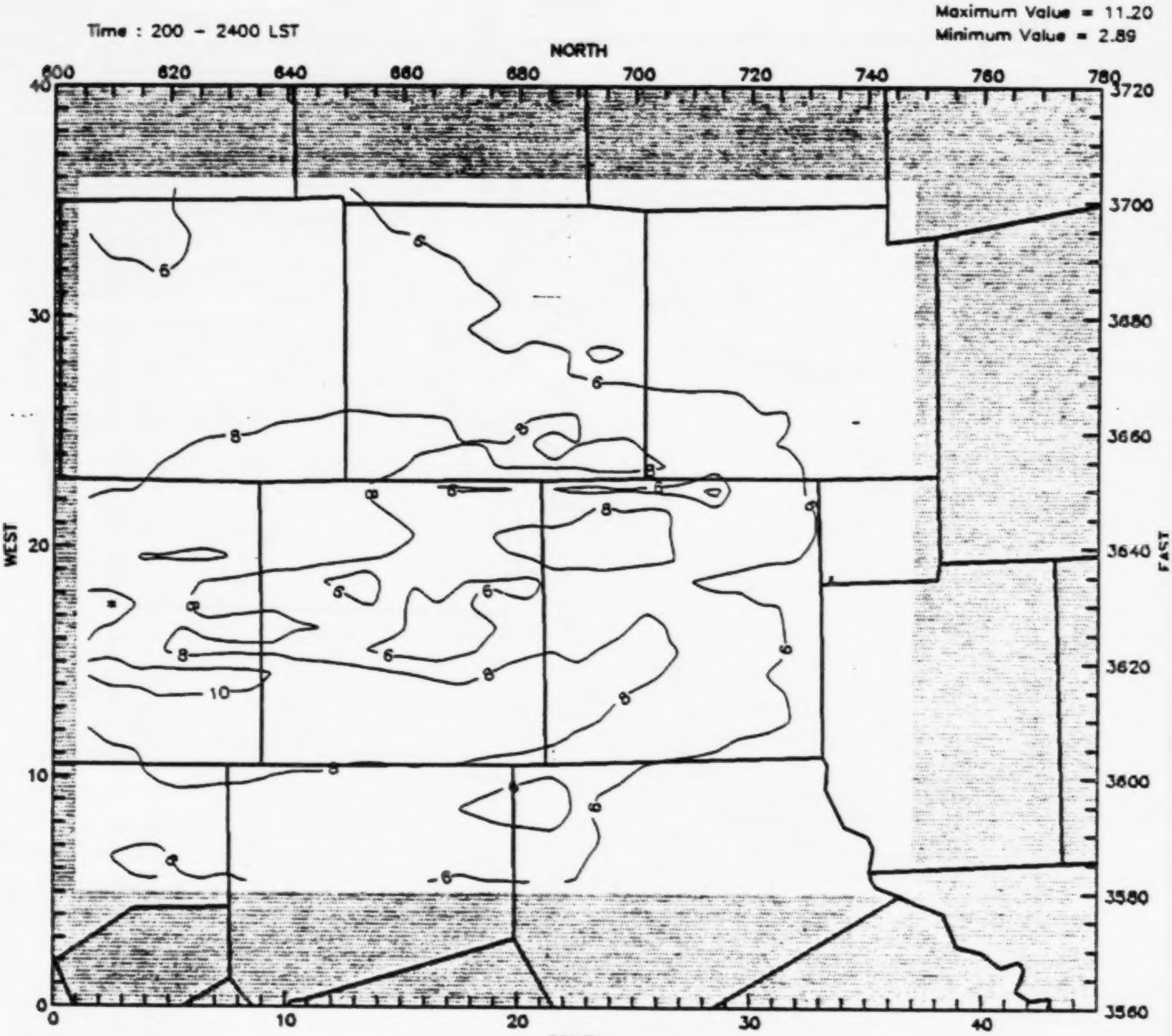
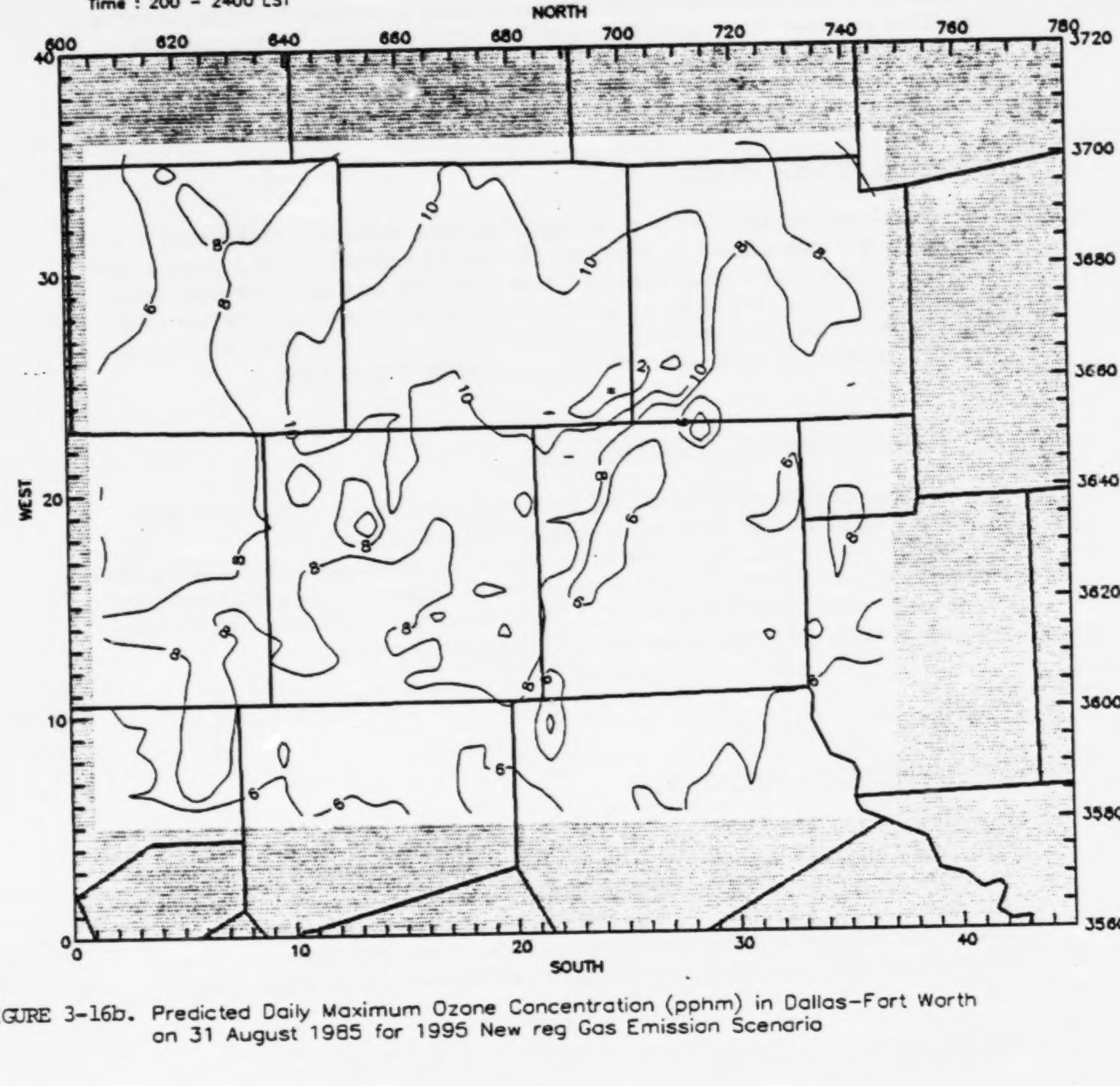

Time : 200 - 2400 LST
Maximum Value = 11.20
Minimum Value = 2.89
NORTH
SOUTH
WEST
EAST
600
620
640
660
680
700
720
740
760
780
3720
3700
3680
3660
3640
3620
3600
3580
3560
0
10
20
30
40
6
8
10

FIGURE 3-16a. Predicted Daily Maximum Ozone Concentration (pphm) in Dallas-Fort Worth on 30 August 1985 for 1995 New Reg Gas Emission Scenario

Maximum Value = 12.97
Minimum Value = 1.91

Time : 200 - 2400 LST


NORTH
600
620
640
660
680
700
720
740
760
780
3720
3700
3680
3660
3640
3620
3600
3580
3560
EAST
40
30
20
10
0
WEST
0
10
20
30
40
SOUTH
10
8
6
2

IGURE 3-16b. Predicted Daily Maximum Ozone Concentration (pphm) in Dallas-Fort Worth on 31 August 1985 for 1995 New reg Gas Emission Scenario reg gas scenario on 30 and 31 August is 11.2 and 13.6 pphm which is a 3 and 5 percent reduction in the peak ozone concentration from the 1995 base case (Table 3-3). Differences in daily maximum ozone concentrations between the 1995 new reg gas and 1995 base case emission scenarios are given in Figure 3-17. Comparisons betwen these two scenarios should be viewed with caution since there has been adjustments of emissions in the mobile sector for changes in speed in addition to the implementation of the proposed new standards for gasoline vehicles. However, the modeling results do indicate that the maximum difference in daily maximum ozone concentrations due to the new gasoline vehicles regulations would be approximately 1 pphm.

100 Percent Methanol (M100)

Use of a 100 percent penetration of methanol powered vehicles in 1995 results in a decrease in the peak ozone concentration (10.7 and 12.4 pphm) of 4 to 5 percent over the 1995 new reg gas emission scenario (Table 3-3). The location of the peak ozone concentration in the 1995 M100 emission scenario is the same as seen for the 1995 new reg gas scenario (Figure 3-18). Decreases in daily maximum ozone concentrations due to the M100 vehicles are as high as 1.7 pphm (Figure 3-19).

100 Percent Compressed Natural Gas (CNG)

Use of 100 percent penetration of CNG vehicles in 1995 results in decreases in the peak ozone concentration (10.5 and 12.2 pphm) of 6 percent over the 1995 new reg gas scenario (Table 3-3). Again, the CNG fuels do not effect the location of the peak ozone concentration (Figure 3-20). There are large regions of ozone reductions due to the use of the CNG fuel (Figure 3-21). Daily maximum ozone concentrations are reduced up to 2.4 pphm due to the use of CNG powerd vehicles.

St. Louis

New Regulations for Gas Vehicles

The implemention of the new gas vehicle regulations results in about a 1 percent reduction in the peak ozone concentration in 1995 St. Louis (Table 3-3). As seen in the isopleths of daily maximum ozone concentrations and DE plots with the 1995 base case (Figures 3-22 and 3-23) the predicted ozone concentrations for the 1995 new reg gas emission scenario are almost identical to the 1995 base case. The maximum difference in the daily maximum ozone concentrations is 0.3 pphm.

100 Percent Methanol (M100)

The use of M100 vehicles in 1995 St. Louis results in a 1 percent decrease in the peak ozone concentration over the 1995 new reg gas emission scenario (Figure 3-24). The

Table 3-3a. Region-wide maximum ozone concentrations (pphm) for observed, current and 1995 base cases.

Strategy	Dallas-Fort Worth		Philadelphia	St. Louis
	August 30	August 31	July 13	July 13
[1]Observed	14.0	17.0	20.5	22.3
[1]Current base	12.4	16.4	23.6	24.4
[2]1995 base	11.6	13.7	18.6	14.5

1 - 1985, 1979, and 1976 are current base years for Dallas-Fort Worth, Philadelphia, and St. Louis, respectively.

2 - The 1995 base emissions projections utilized vehicle speeds based on the NAPAP inventory; these speeds are generally higher than the 20 mph used in the fuel strategies in Table 3-3b, below. Care should be taken when comparing results from this strategy with those below since a 20 mph assumption would increase the 1995 base emissions.

Table 3-3b. Region-wide maximum ozone concentrations (pphm) for 1995 fuel strategies.

Strategy	Dallas-Fort Worth		Philadelphia	St. Louis
	August 30	August 31	July 13	July 13
New Gas Regs	11.2	13.0	18.2	14.3
M100	10.7	12.4	18.2	14.1
CNG	10.5	12.2	18.0	13.9

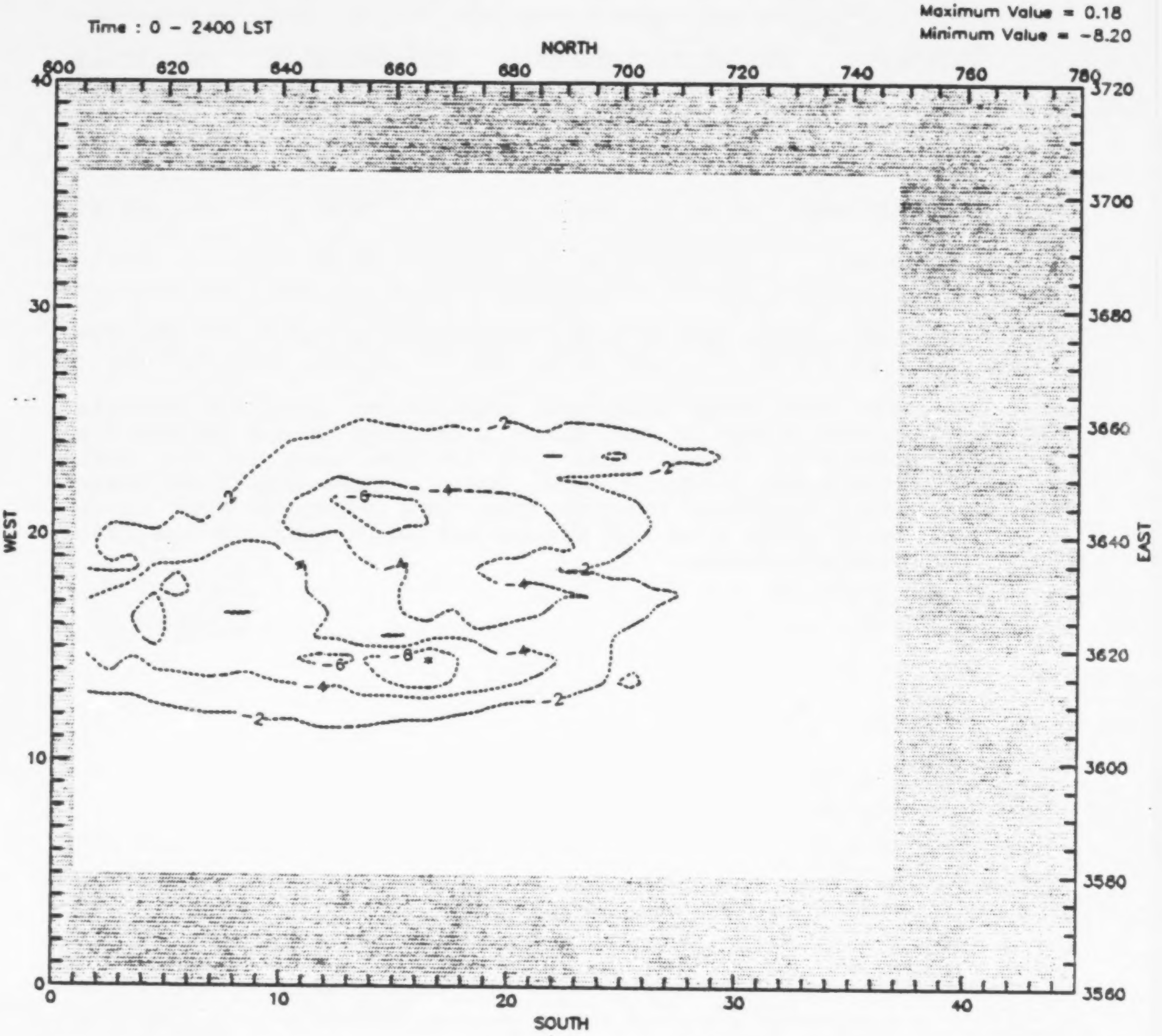

Time : 0 - 2400 LST
Maximum Value = 0.18
Minimum Value = -8.20
NORTH
600
620
640
660
680
700
720
740
760
780
3720
3700
3680
3660
3640
3620
3600
3580
3560
EAST
WEST
40
30
20
10
0
0
10
20
30
40
SOUTH
-2
-4
-6
-8

FIGURE 3-17a. Differences in Daily Maximum Ozone Concentrations (ppb) between 1995 base case and 1995 new reg gas emission scenarios (new reg gas - base) in Dallas-Fort Worth on 30 August 1985.

96 16

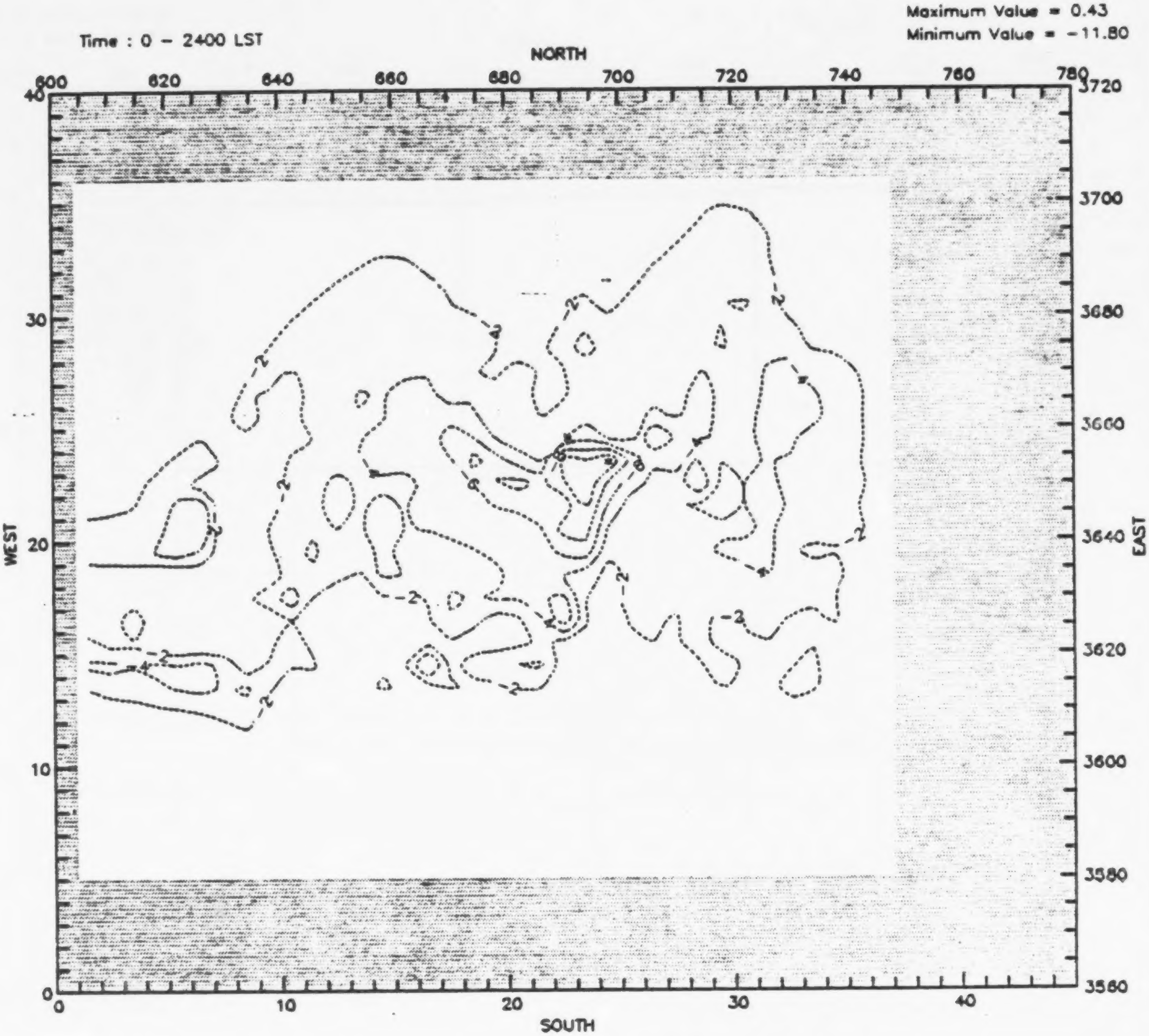
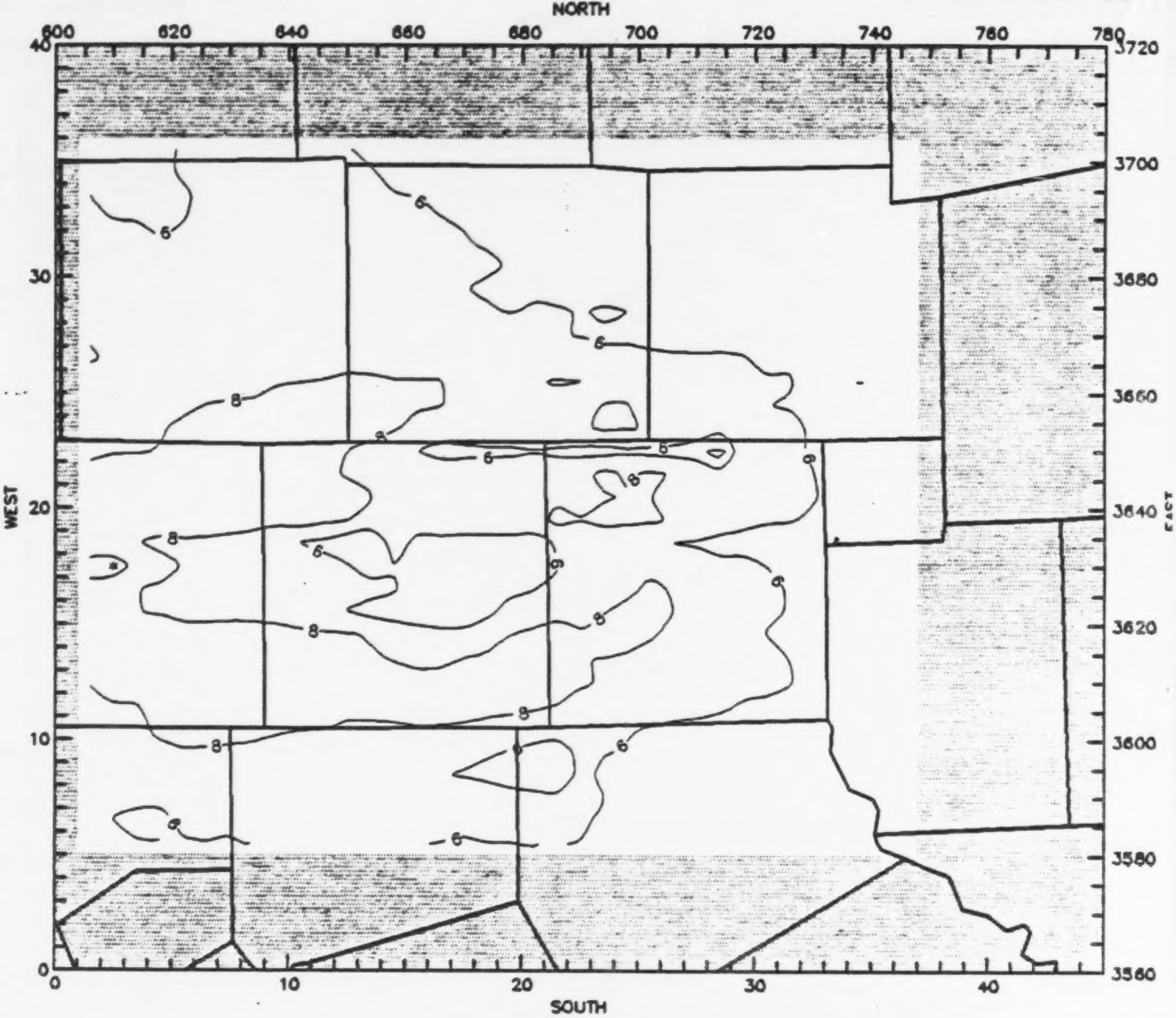

Maximum Value = 0.43
Minimum Value = -11.80
Time : 0 - 2400 LST
NORTH
SOUTH
WEST
EAST
600
620
640
660
680
700
720
740
760
780
3720
3700
3680
3660
3640
3620
3600
3580
3560
0
10
20
30
40
-2
-4
-6
-8

FIGURE 3-17b. Differences in Daily Maximum Ozone Concentrations (ppb) between 1995 base case and 1995 new reg gas emission scenarios (new reg gas - base) in Dallas-Fort Worth on 31 August 1985.


NORTH
600
620
640
660
680
700
720
740
760
780
40
30
20
10
0
WEST
3720
3700
3680
3660
3640
3620
3600
3580
3560
EAST
0
10
20
30
40
SOUTH
6
8
6
8
6
8
8
6
9
9
8
8
8
6
6
6
6

Time : 200 - 2400 LST

Maximum Value = 10.72
Minimum Value = 2.81

FIGURE 3-18a. Predicted Daily Maximum Ozone Concentration (pphm) in Dallas-Fort Worth on 30 August 1985 for 1995 M100 Emission Scenario

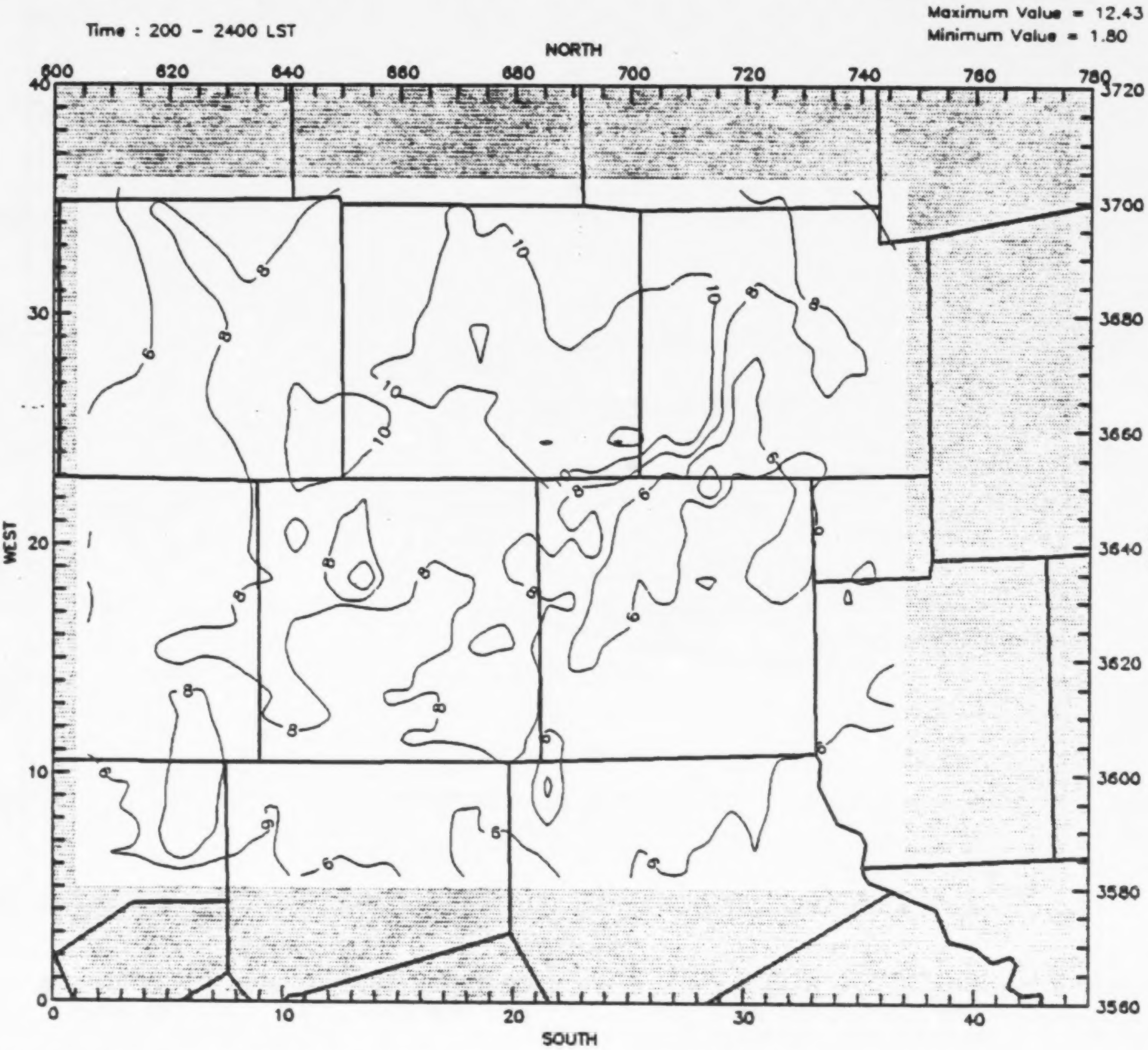

Time : 200 - 2400 LST
Maximum Value = 12.43
Minimum Value = 1.80
NORTH
SOUTH
WEST
EAST
600
620
640
660
680
700
720
740
760
780
3720
3700
3680
3660
3640
3620
3600
3580
3560
0
10
20
30
40
10
8
6

FIGURE 3-18b. Predicted Daily Maximum Ozone Concentration (pphm) in Dallas-Fort Worth on 31 August 1985 for 1995 M100 Emission Scenario

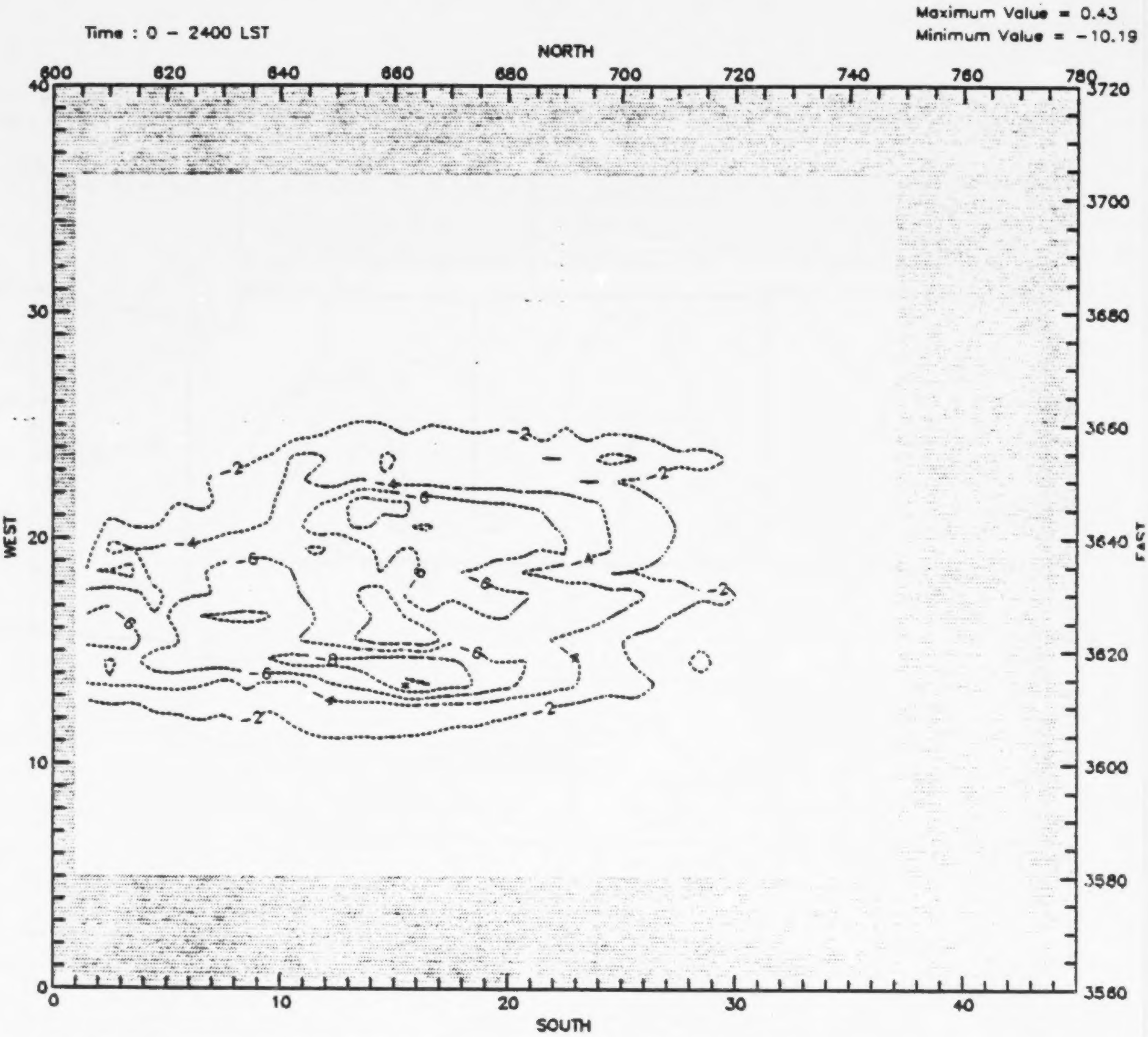
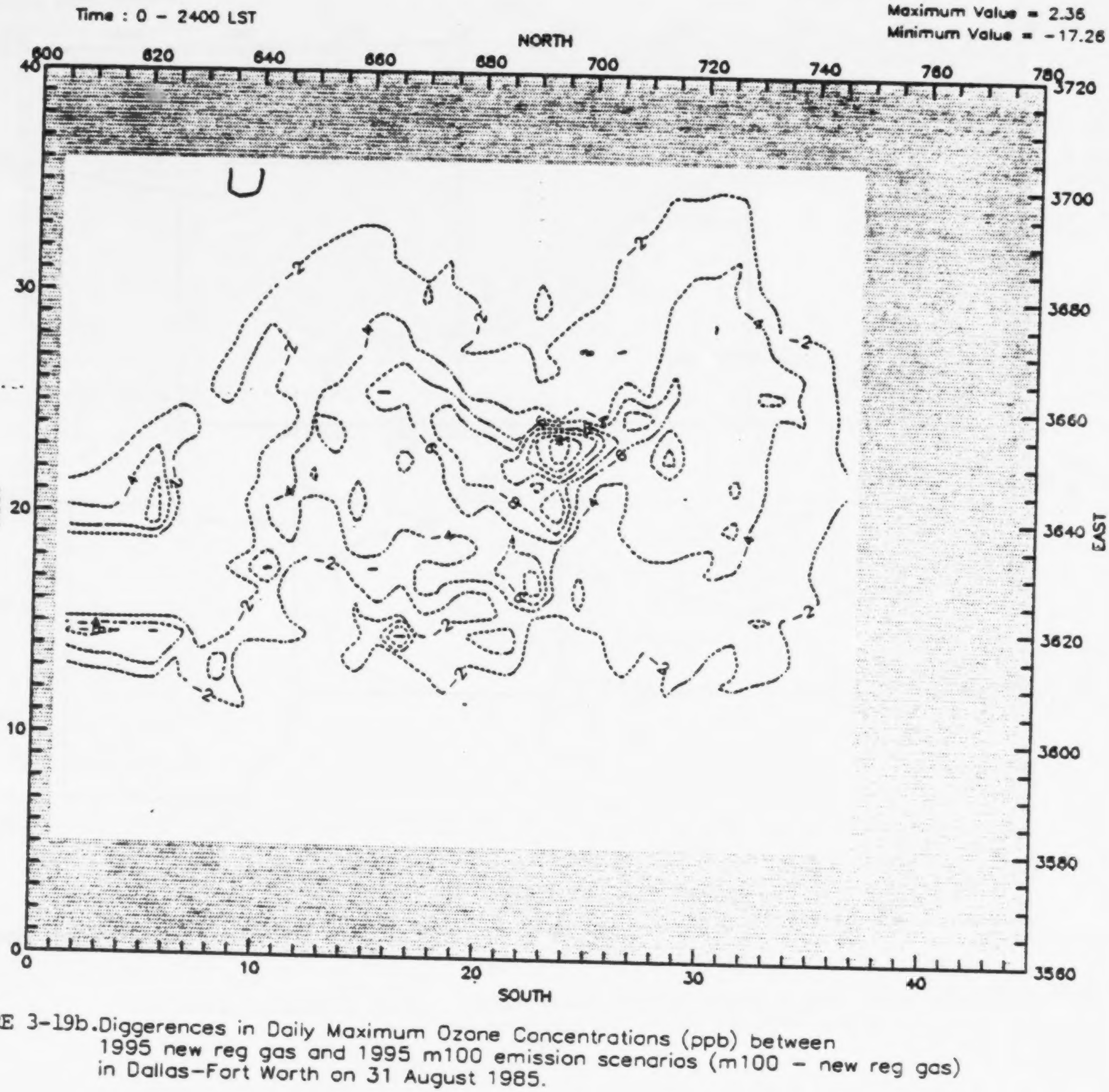


FIGURE 3-19a. Differences in Daily Maximum Ozone Concentrations (ppb) between 1995 new reg gas and 1995 m100 emission scenarios (m100 - new reg gas) in Dallas-Fort Worth on 30 August 1985.


Time : 0 - 2400 LST
Maximum Value = 2.36
Minimum Value = -17.26
NORTH
SOUTH
WEST
EAST
600
620
640
660
680
700
720
740
760
780
3720
3700
3680
3660
3640
3620
3600
3580
3560
0
10
20
30
40
-2
-4
-6
-8

IGURE 3-19b. Diggerences in Daily Maximum Ozone Concentrations (ppb) between 1995 new reg gas and 1995 m100 emission scenarios (m100 – new reg gas) in Dallas–Fort Worth on 31 August 1985.

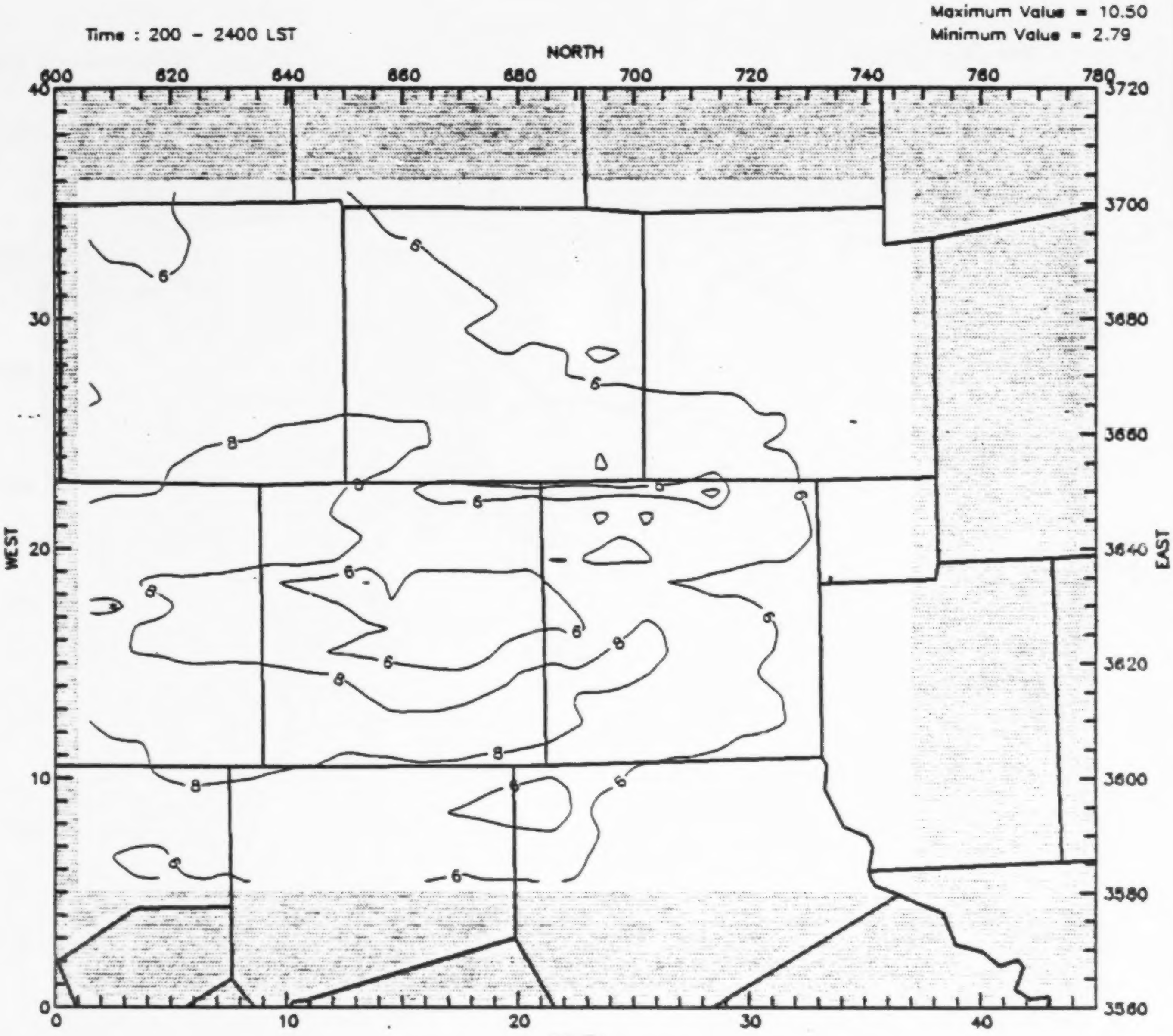

Maximum Value = 10.50
Minimum Value = 2.79
Time : 200 - 2400 LST
NORTH
SOUTH
WEST
EAST
600
620
640
660
680
700
720
740
760
780
3720
3700
3680
3660
3640
3620
3600
3580
3560
0
10
20
30
40
6
8

FIGURE 3-20a. Predicted Daily Maximum Ozone Concentration (pphm) in Dallas-Fort Worth on 30 August 1985 for 1995 CNG Emission Scenario

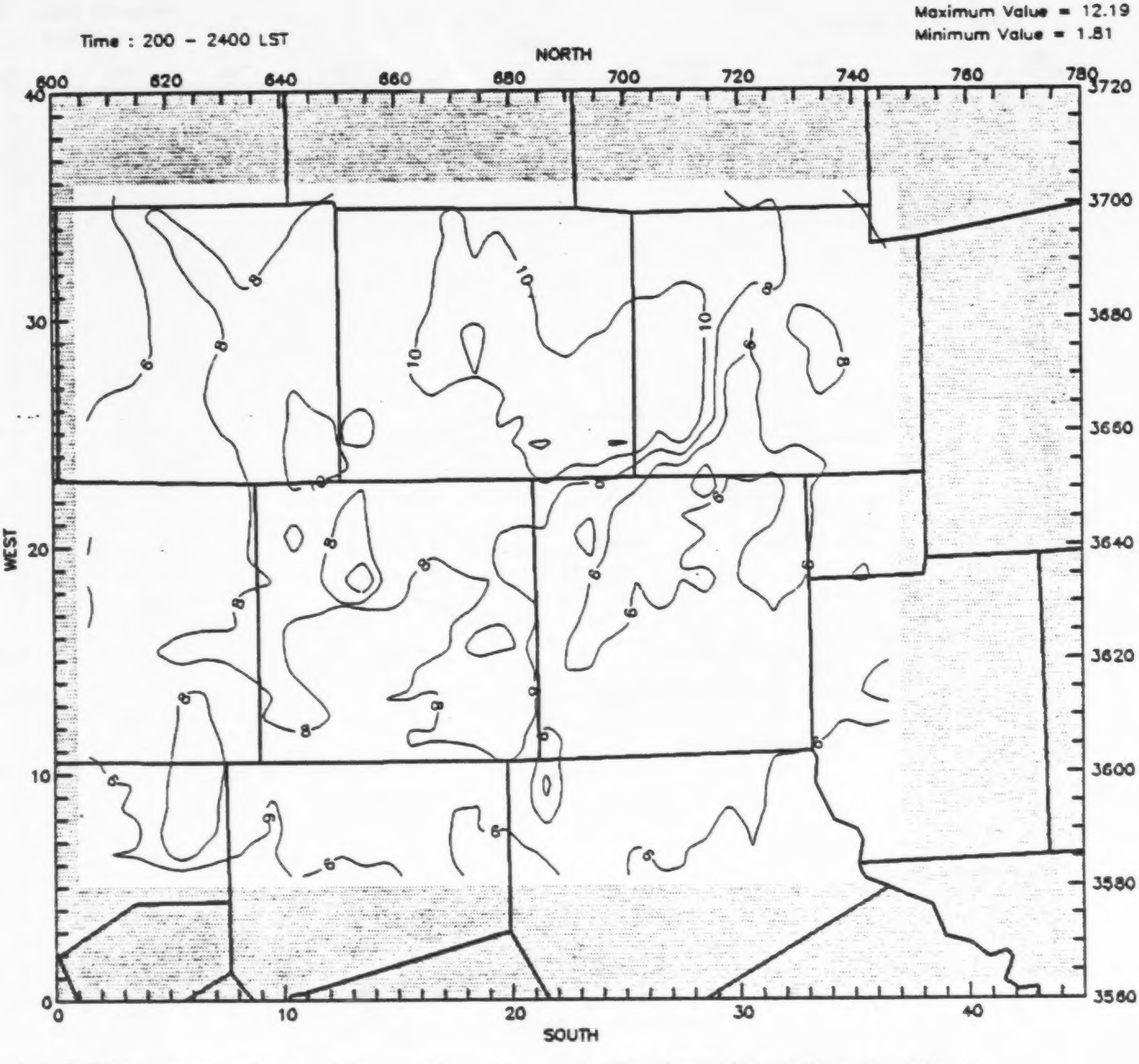

Maximum Value = 12.19
Minimum Value = 1.81
Time : 200 - 2400 LST
NORTH
SOUTH
WEST
EAST
600
620
640
660
680
700
720
740
760
780
3720
3700
3680
3660
3640
3620
3600
3580
3560
0
10
20
30
40
6
8
10

FIGURE 3-20b. Predicted Daily Maximum Ozone Concentration (pphm) in Dallas-Fort Worth on 31 August 1985 for 1995 CNG Emission Scenario

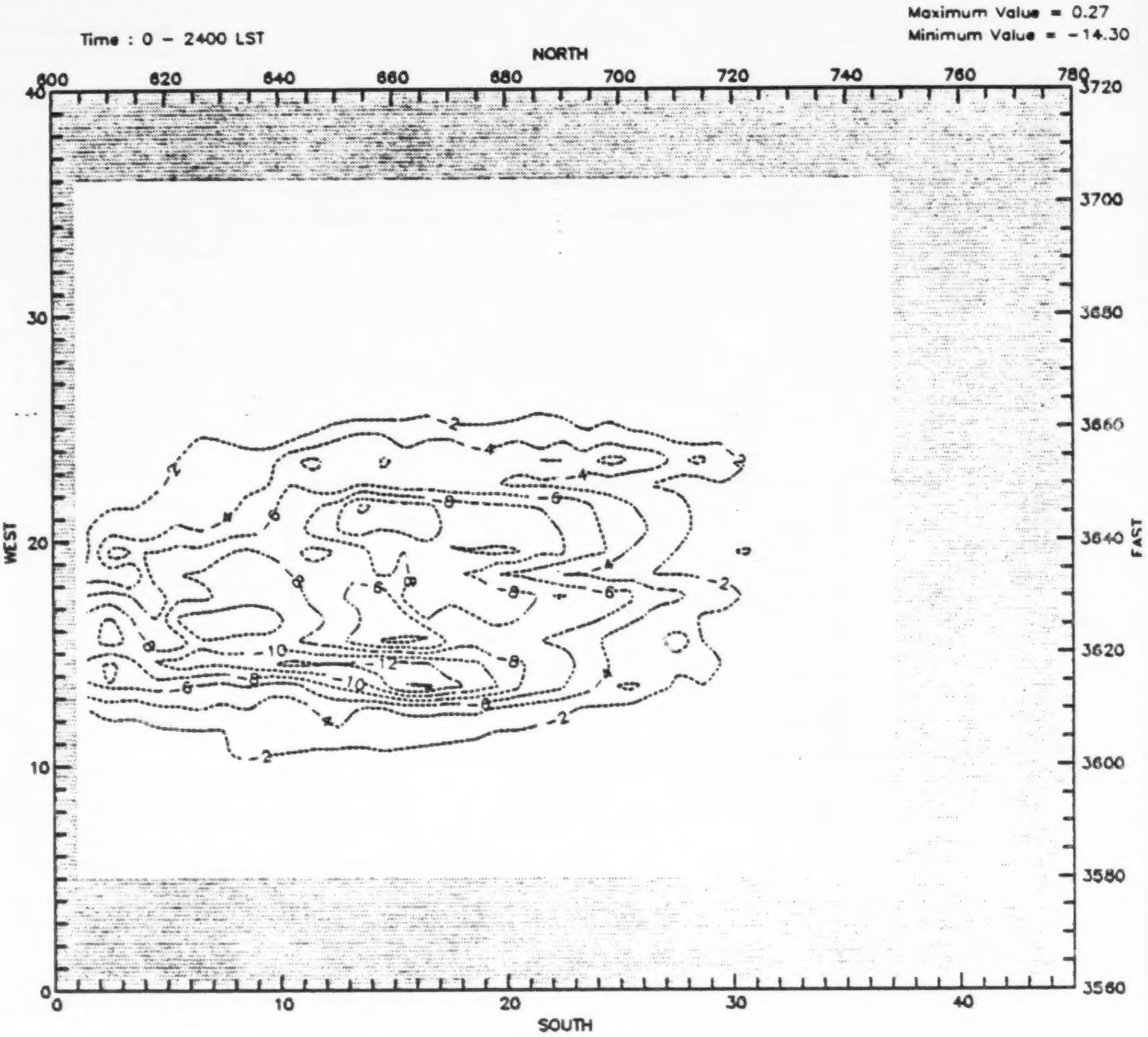

Maximum Value = 0.27
Minimum Value = -14.30
Time : 0 - 2400 LST
NORTH
600
620
640
660
680
700
720
740
760
780
3720
3700
3680
3660
3640
3620
3600
3580
3560
EAST
40
30
20
10
0
WEST
0
10
20
30
40
SOUTH
-2
-4
-6
-8
-10
-12

FIGURE 3-21a. Differences in Daily Maximum Ozone Concentrations (ppb) between 1995 new reg gas and 1995 cng emission scenarios (cng - new reg gas) in Dallas-Fort Worth on 30 August 1985.

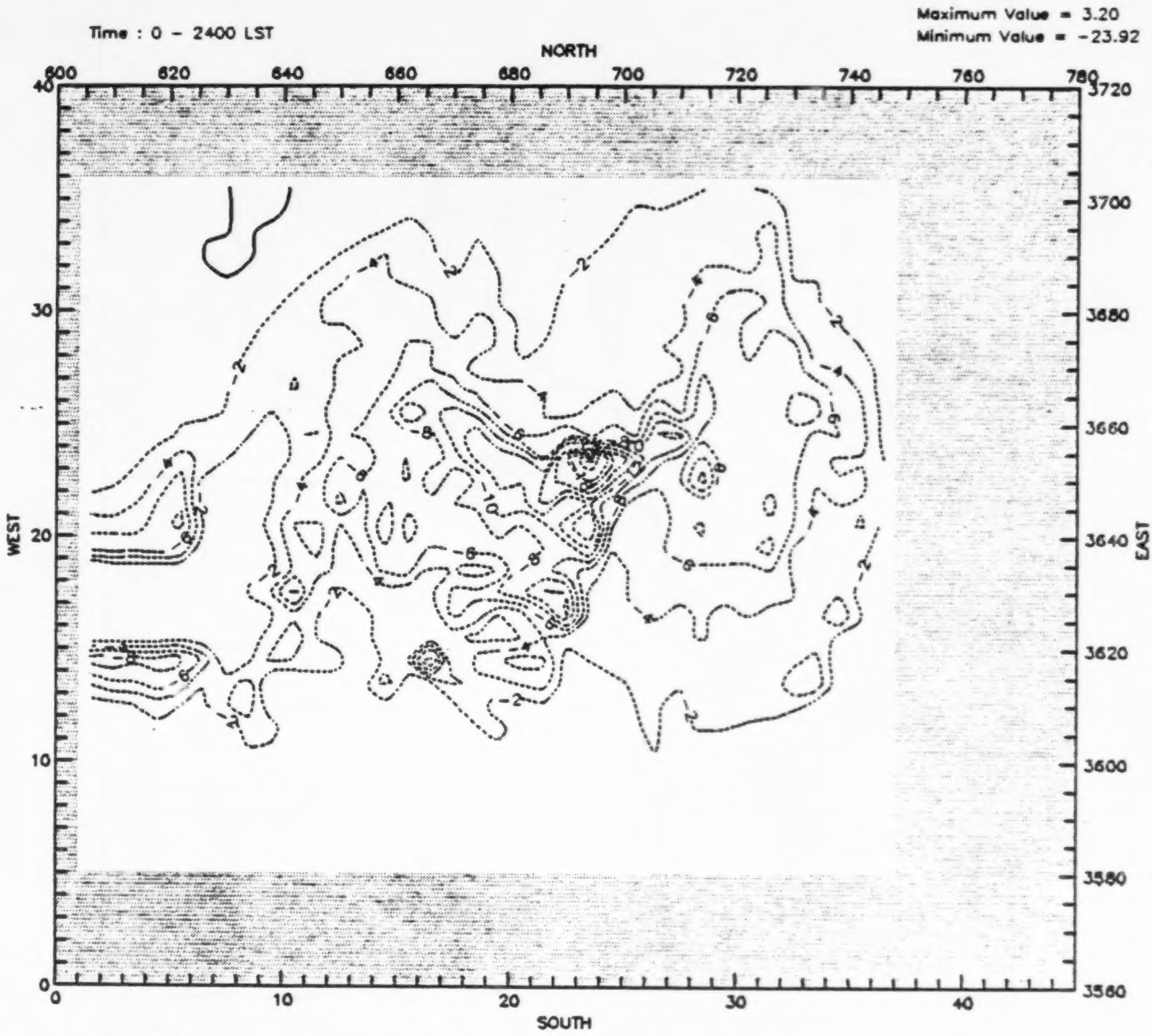

Time : 0 - 2400 LST
Maximum Value = 3.20
Minimum Value = -23.92
NORTH
SOUTH
WEST
EAST
600
620
640
660
680
700
720
740
760
780
3720
3700
3680
3660
3640
3620
3600
3580
3560
0
10
20
30
40
-2
-4
-6
-8
-10

FIGURE 3-21b. Diggerences in Daily Maximum Ozone Concentrations (ppb) between 1995 new reg gas and 1995 cng emission scenarios (cng – new reg gas) in Dallas–Fort Worth on 31 August 1985.

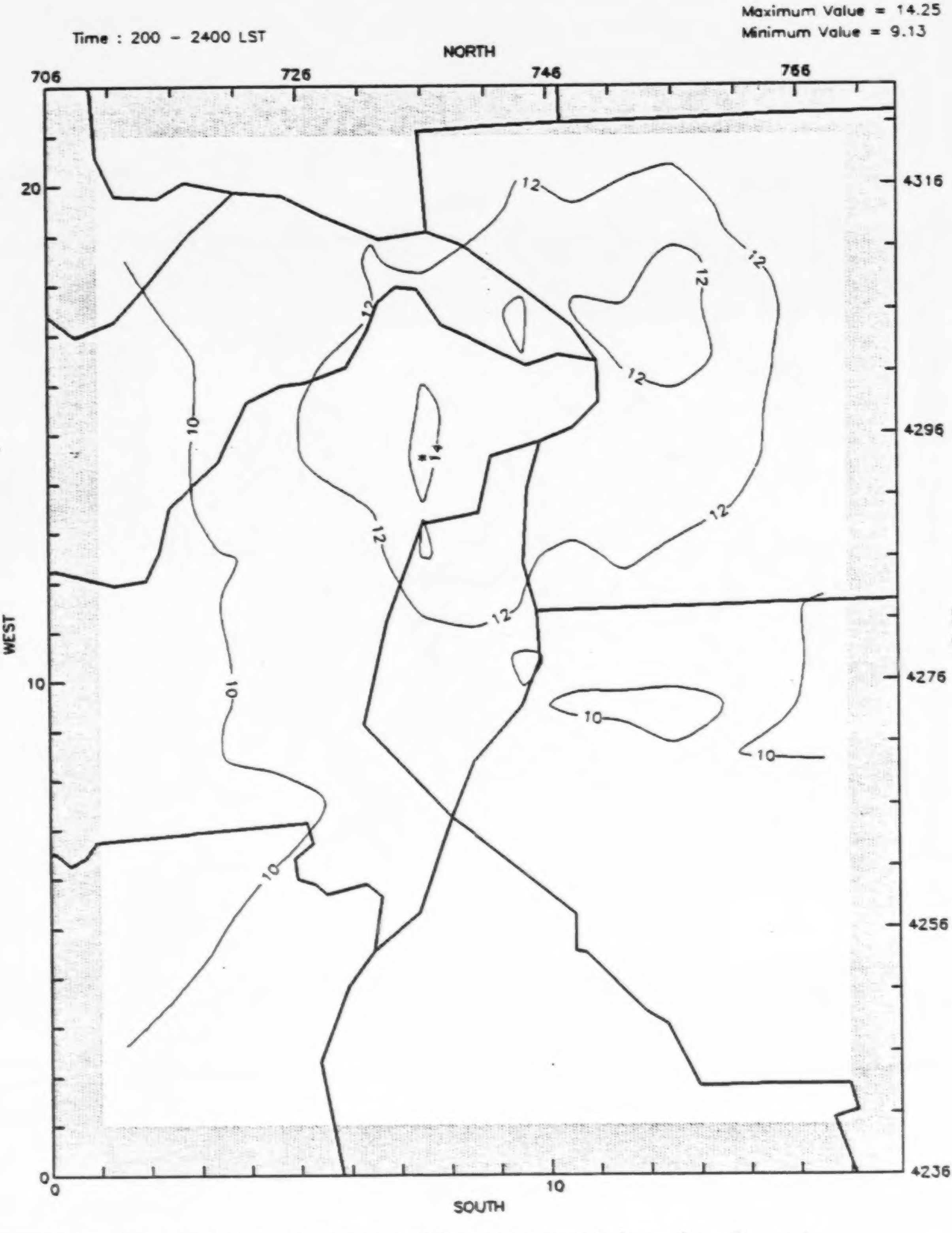
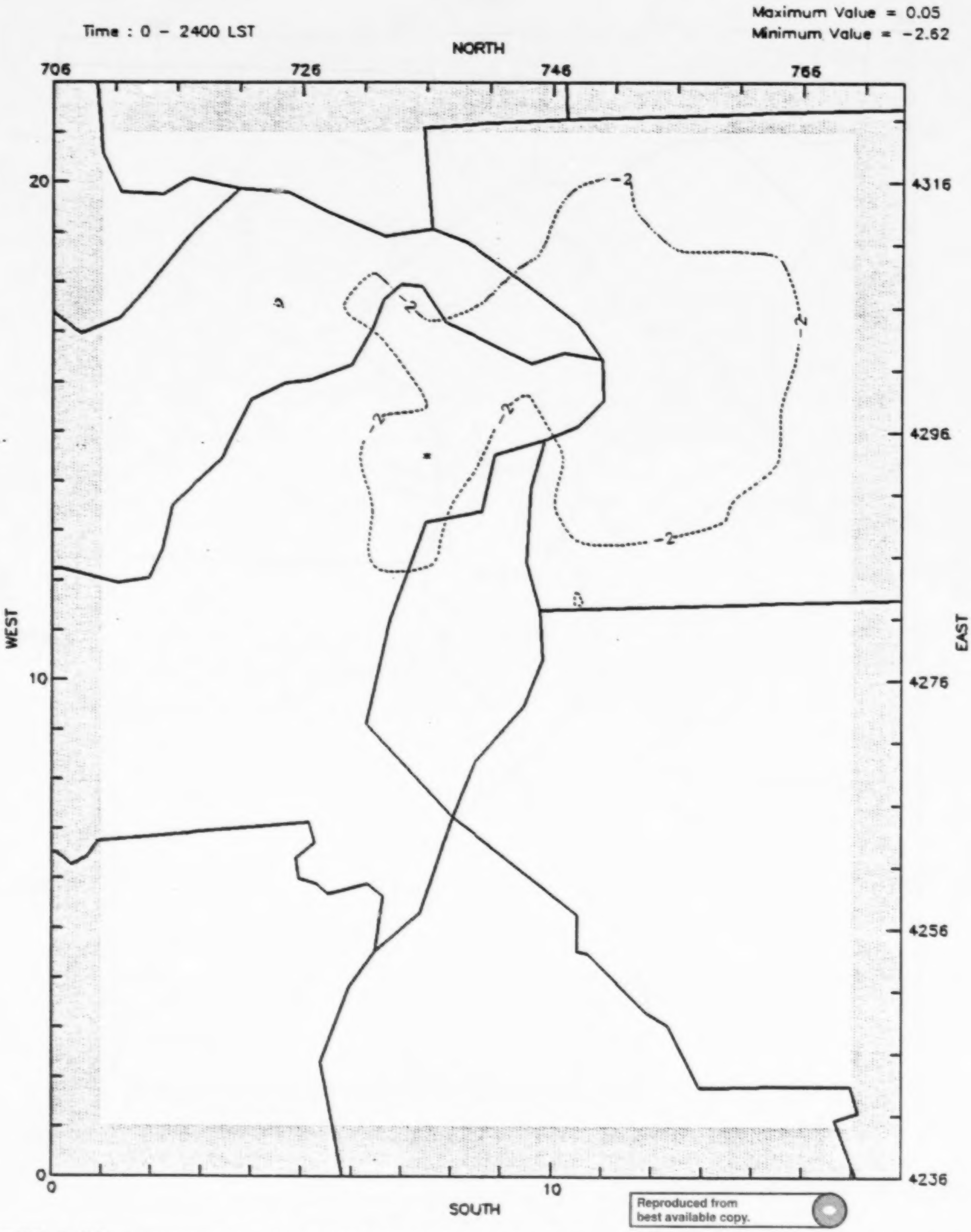

Maximum Value = 14.25
Minimum Value = 9.13
Time : 200 - 2400 LST
NORTH
706
726
746
766
20
10
0
WEST
EAST
4316
4296
4276
4256
4236
0
10
SOUTH
12
12
12
12
12
12
12
12
14
10
10
10
10
10

FIGURE 3-22. Predicted Daily Maximum Ozone Concentration (pphm) in St. Louis on 13 July 1976 for 1995 New Reg Gas Emission Scenario


Time : 0 - 2400 LST
Maximum Value = 0.05
Minimum Value = -2.62
NORTH
706
726
746
766
20
10
0
WEST
EAST
4316
4296
4276
4256
4236
0
10
SOUTH
-2
-2
-2
-2
-2
0
0

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URE 3-23. Differences in Daily Maximum Ozone Concentrations (ppb) between 1995 base case and 1995 new reg gas emission scenarios (new reg gas − base)

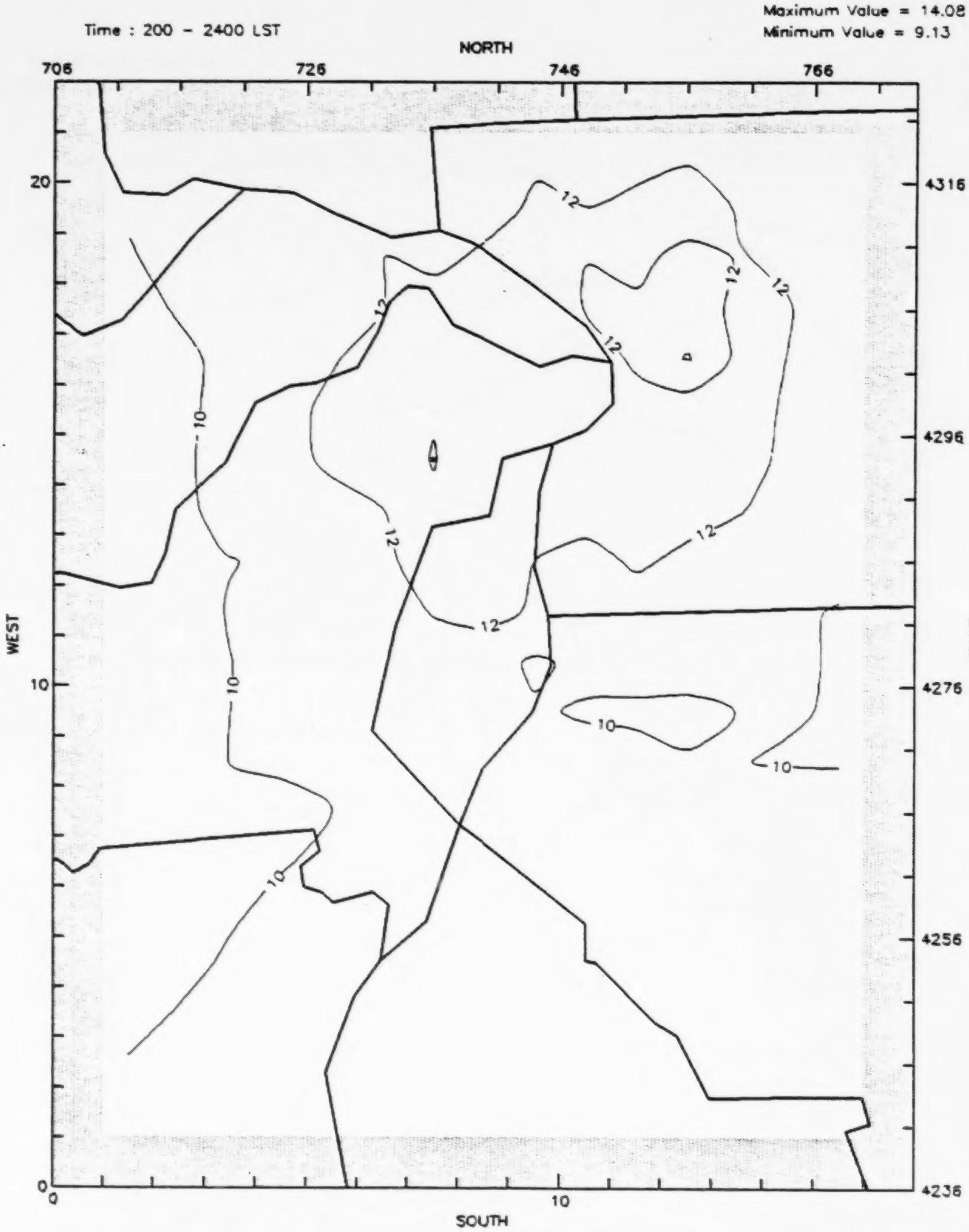

Time : 200 - 2400 LST
Maximum Value = 14.08
Minimum Value = 9.13
NORTH
706
726
746
766
20
10
0
WEST
EAST
4316
4296
4276
4256
4236
0
10
SOUTH
12
12
12
12
12
12
12
10
10
10
10
10

FIGURE 3-24. Predicted Daily Maximum Ozone Concentration (pphm) in St. Louis on 13 July 1976 for 1995 M100 Emission Scenario

predicted ozone concentrations for the 1995 M100 emissions scenario are very similar to the 1995 new reg gas emission scenario (Figure 3-25) with a maximum decrease in daily maximum ozone concentrations of 0.4 pphm.

100 Percent Compressed Natural Gas (CNG)

Use of CNG fuel results in larger decreases in ozone concentrations over the 1995 new reg gas scenario than exhibited by the M100 fuel scenarios. The peak ozone concentration is reduced by 3 percent (Table 3-3 and Figure 3-26) and the maximum decrease in daily maximum ozone concentrations is 0.6 pphm (Figure 3-27).

Philadelphia

For the Philadelphia 1995 emission scenarios initial and boundary conditions were adjusted based on observed changes in national emission trends from 1979 to 1985 and projected changes in emissions taken from the 1985 and 1995 base case emission scenarios. Initial and boundary conditions in 1995 for the other cities were not modified because "clean" values were used (Morris et al., 1989b,c; Morris Myers, and Carr 1989).

1995 Base Case

Isopleths of daily maximum ozone concentrations for the Philadelphia 1995 Base Case is given in Figure 3-28. The peak predicted ozone concentration is 18.6 pphm and occurs approximately 10 km to the north of downtown Philadelphia. The 1979 Base Case predicted a peak ozone concentration of 25.6 pphm. Since there is considerable increase in VOC emissions (79 percent) and NO_x emissions (29 percent) between the 1979 and 1995 base case emission inventories, the reduction in the peak ozone concentration must be due to the reduction in initial and boundary conditions. The 1995 base case emission inventory has higher emissions than the 1979 base case due to the inclusion of many previously uninventoried sources. Thus despite these increases, based on national emission trends and projections it is projected that VOC and NO_x emissions will go down between 1979 and 1995.

New Regulations for Gas Vehicles

Isopleths of daily maximum oozne concentrations for the 1995 new reg gas emission scenario are given in Figure 3-29. Differences between the 1995 new reg gas and 1995 base case emission scenarios are given in Figure 3-30. The new gasoline vehicle regulations is estimated to reduce the peak ozone concentrations by approximtaely 2 percent. The maximum reduction in the daily maximum ozone concentration is estimated to be around 0.5 pphm. Again, because of the differences in speed used in the

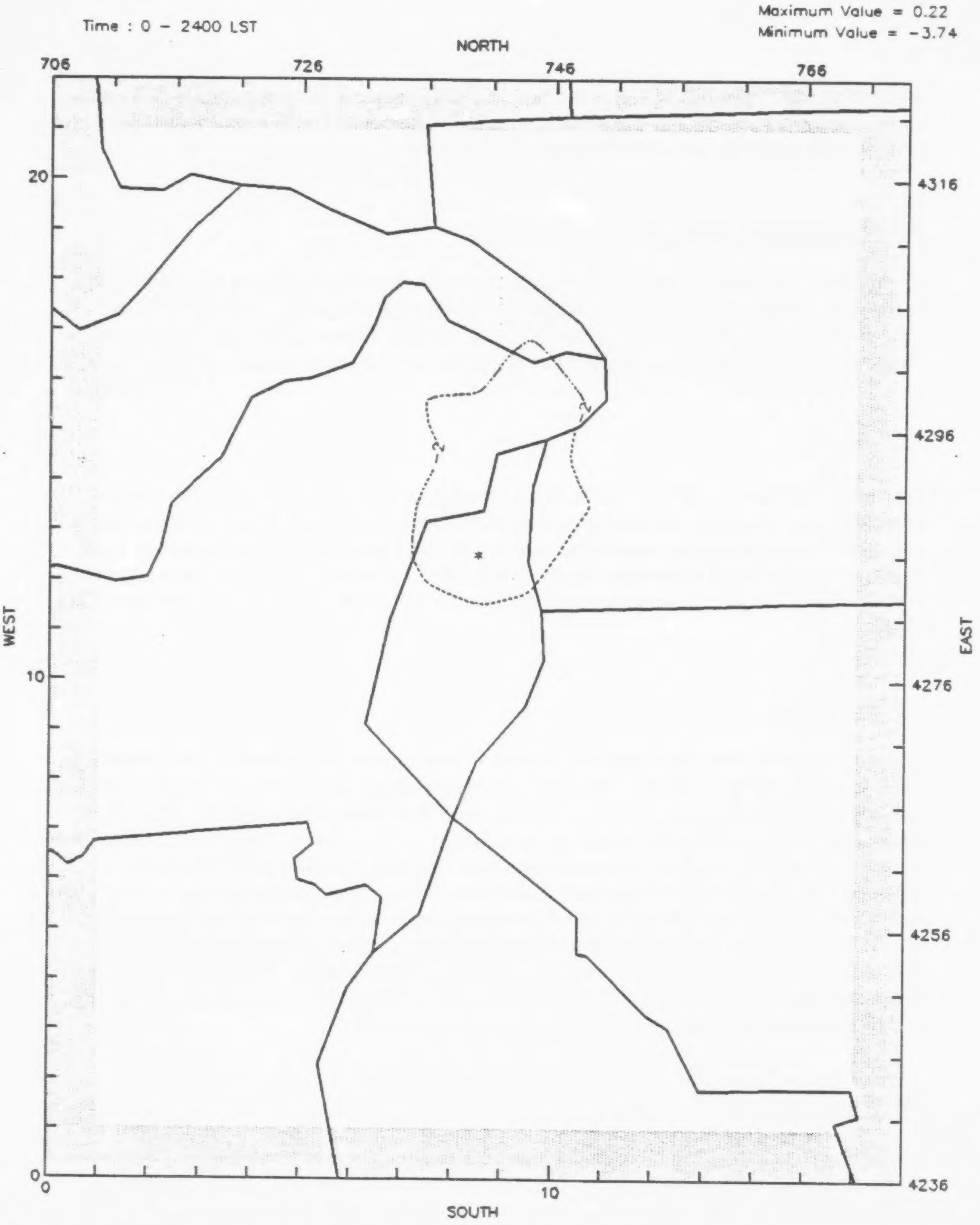
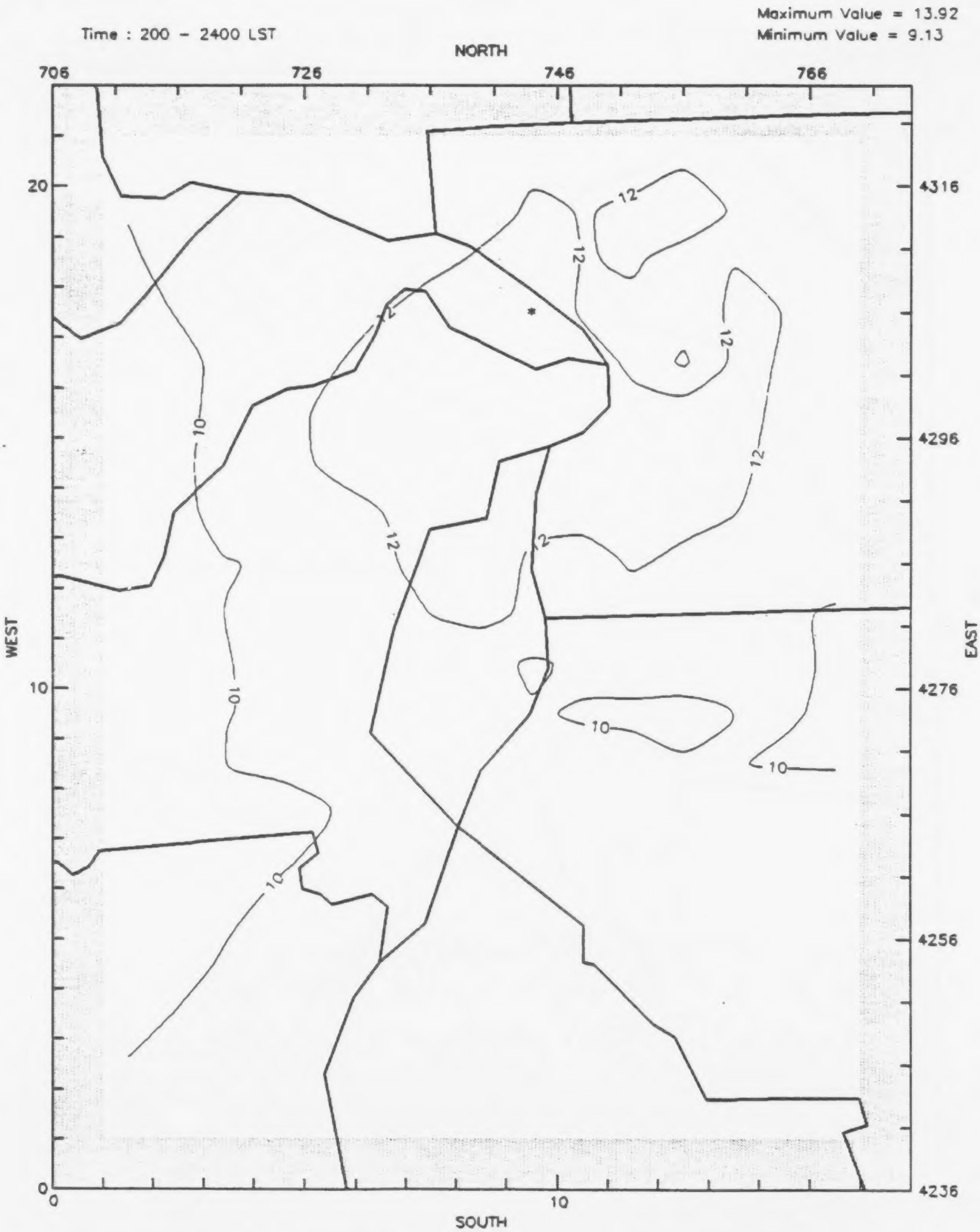
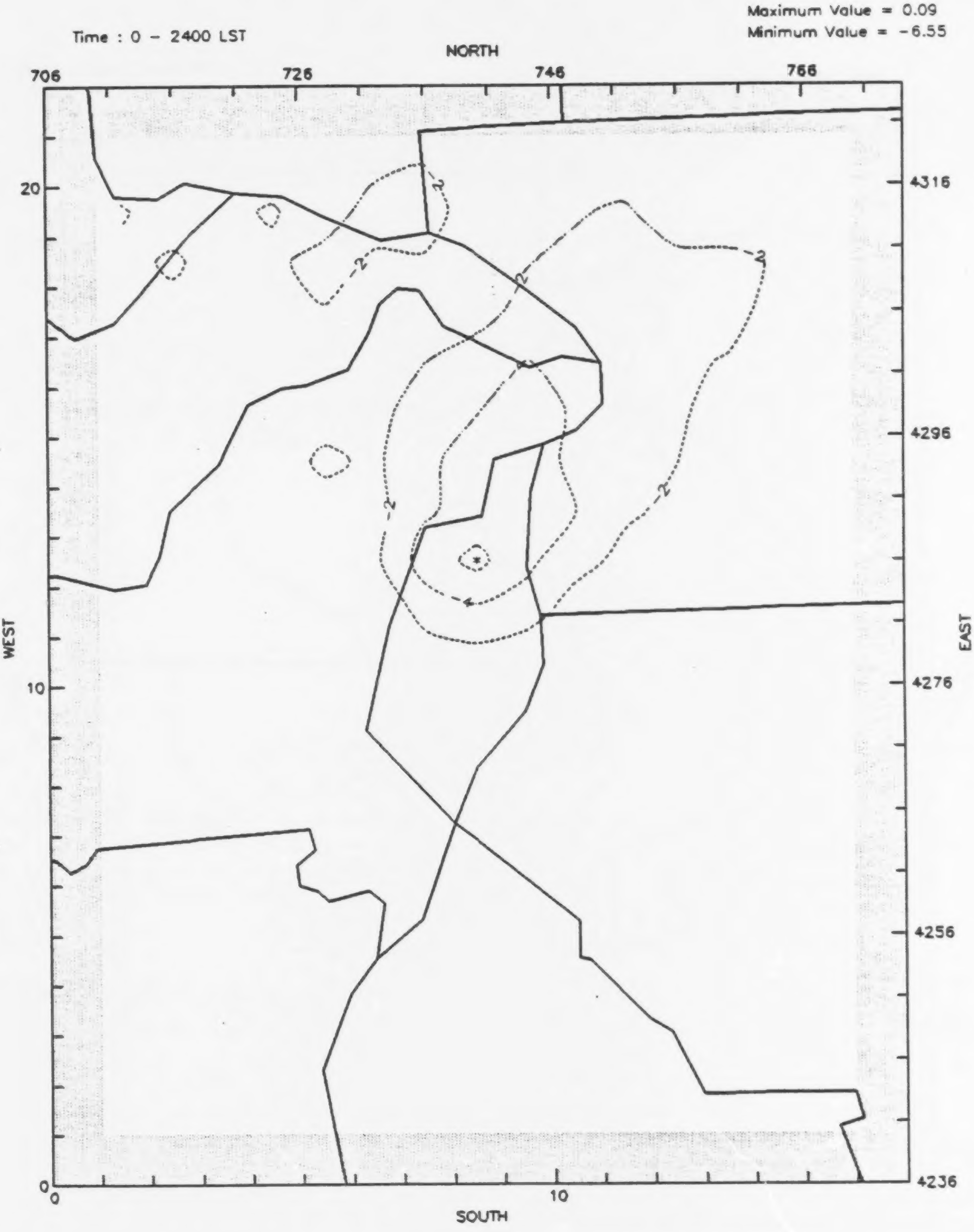

Time : 0 - 2400 LST
Maximum Value = 0.22
Minimum Value = -3.74
NORTH
706
726
746
766
20
10
0
4316
4296
4276
4256
4236
WEST
EAST
-2
-2
*
0
10
SOUTH

FIGURE 3-25. Differences in Daily Maximum Ozone Concentrations (ppb) between 1995 new reg gas and 1995 M100 emission scenarios (M100 - new reg gas) in St. Louis on 13 July 1976.


Time : 200 - 2400 LST
Maximum Value = 13.92
Minimum Value = 9.13
NORTH
706
726
746
766
20
10
0
WEST
EAST
4316
4296
4276
4256
4236
0
10
SOUTH
12
12
12
12
12
12
12
10
10
10
10
10

URE 3-26. Predicted Daily Maximum Ozone Concentration (pphm) in St. Louis on 13 July 1976 for 1995 CNG Emission Scenario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726
746
766
20
10
0
WEST
EAST
4316
4296
4276
4256
4236
0
10
SOUTH
-2
-2
-2
-2
-2
-4

FIGURE 3-27. Differences in Daily Maximum Ozone Concentrations (ppb) between 1995 new reg gas and 1995 CNG emission scenarios (CNG - new reg gas) in St. Louis on 13 July 1976.

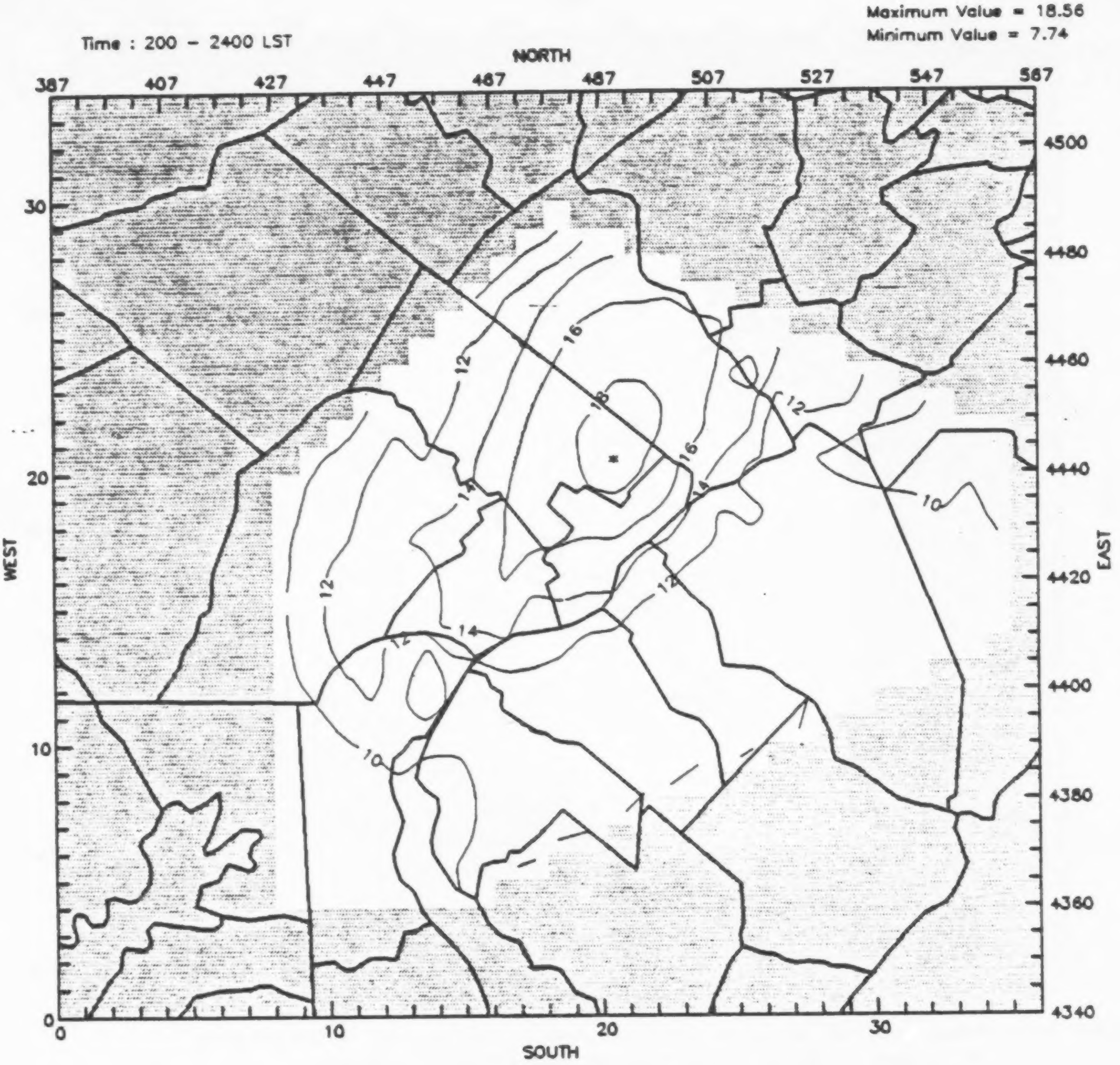
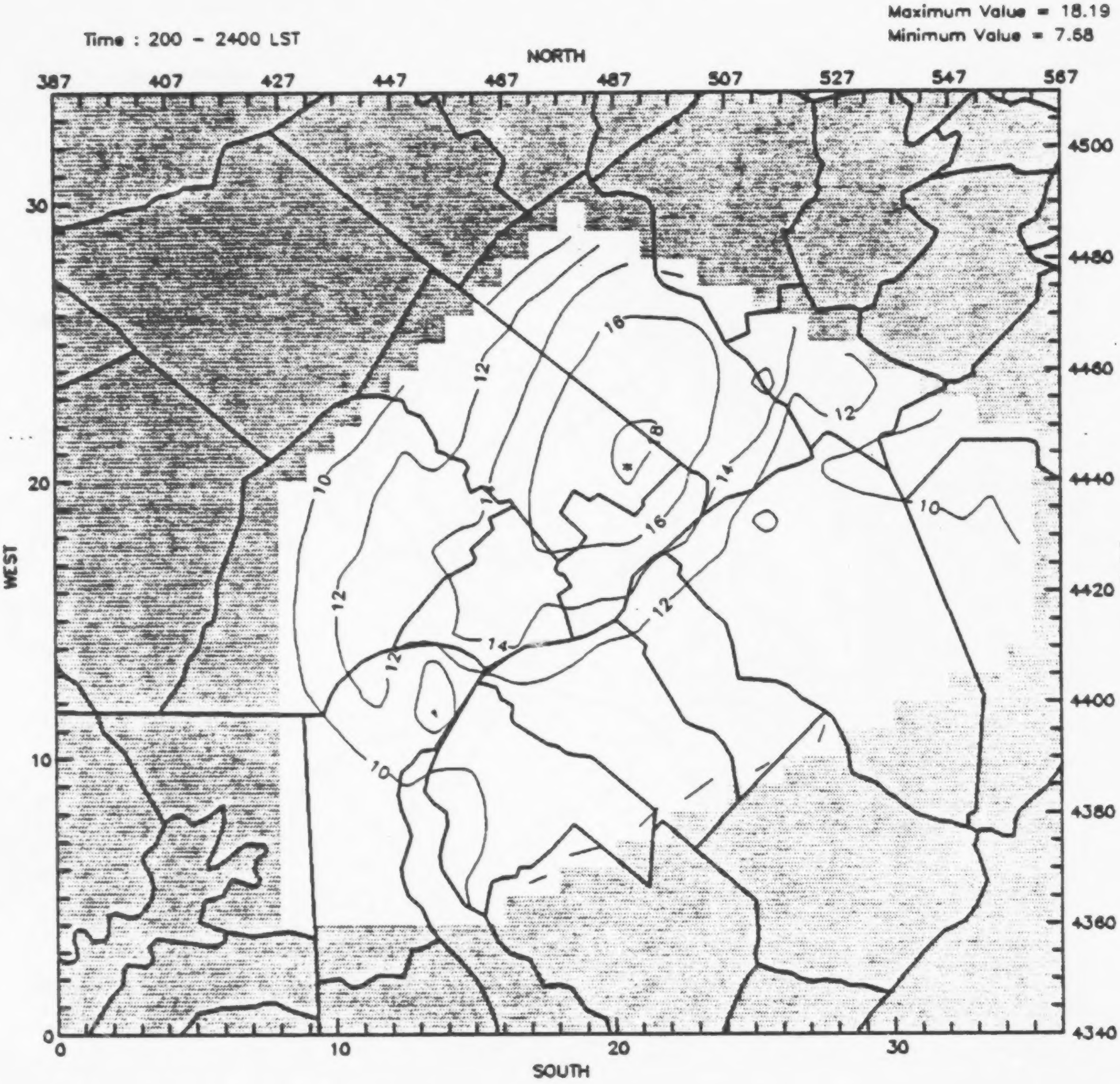

Maximum Value = 18.56
Minimum Value = 7.74
Time : 200 - 2400 LST
NORTH
387
407
427
447
467
487
507
527
547
567
4500
4480
4460
4440
4420
4400
4380
4360
4340
EAST
30
20
10
0
WEST
0
10
20
30
SOUTH
18
16
14
12
10

FIGURE 3-28. Predicted Daily Maximum Ozone Concentration (pphm) in Philadelphia on 13 July 1979 for 1995 Base Case Emission Scenario


Maximum Value = 18.19
Minimum Value = 7.68
Time : 200 - 2400 LST
NORTH
387
407
427
447
467
487
507
527
547
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4480
4460
4440
4420
4400
4380
4360
4340
EAST
30
20
10
0
WEST
0
10
20
30
SOUTH
18
16
14
12
10

FIGURE 3-29. Predicted Daily Maximum Ozone Concentration (pphm) in Philadelphia on 13 July 1979 for 1995 New Reg Gas Emission Scenario

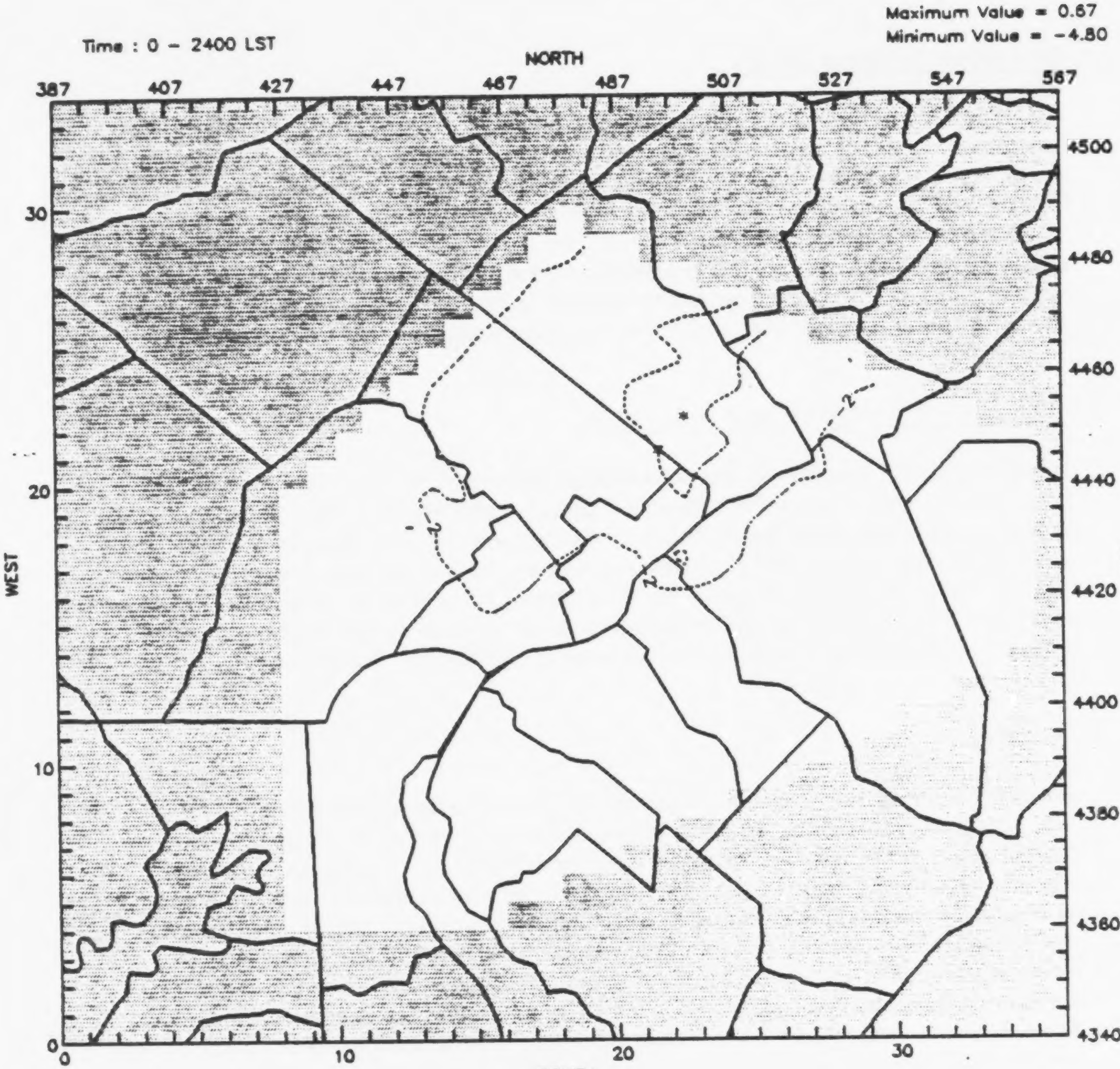

Maximum Value = 0.67
Minimum Value = -4.80
Time : 0 - 2400 LST
NORTH
SOUTH
WEST
EAST
387
407
427
447
467
487
507
527
547
567
4500
4480
4460
4440
4420
4400
4380
4360
4340
0
10
20
30
-2

FIGURE 3-30. Differences in Daily Maximum Ozone Concentrations (ppb) between 1995 base case and 1995 new reg gas emission scenarios (new reg gas - base) in Philadelphia on 13 July 1979.

development of the 1995 base case and 1995 alternative fuel scenarios, care should be taken in the interpretation of these results,.

100 Percent Methanol (M100)

The use of 100 percent penetration of M100 powered vehicles in 1995 Philadelphia has almost no effect on ozone concentrations when compared to the 1995 new reg gas emission scenario (Table 3-3 and Figure 3-31 and 3-32). As seen in the DE plot (Figure 3-32) the maximum increase and decrease in daily maximum ozone concentrations due to the M100 fuel is 0.1 and 0.3 pphm, respectively. The lack of any effect of the M100 vehicles in Philadelphia is due to several factors including the large amount of transported pollutants (initial and boundary conditions) in the region and the large amount of VOC emissions from nonmobile sources in the region.

100 Percent Compressed Natural Gas (CNG)

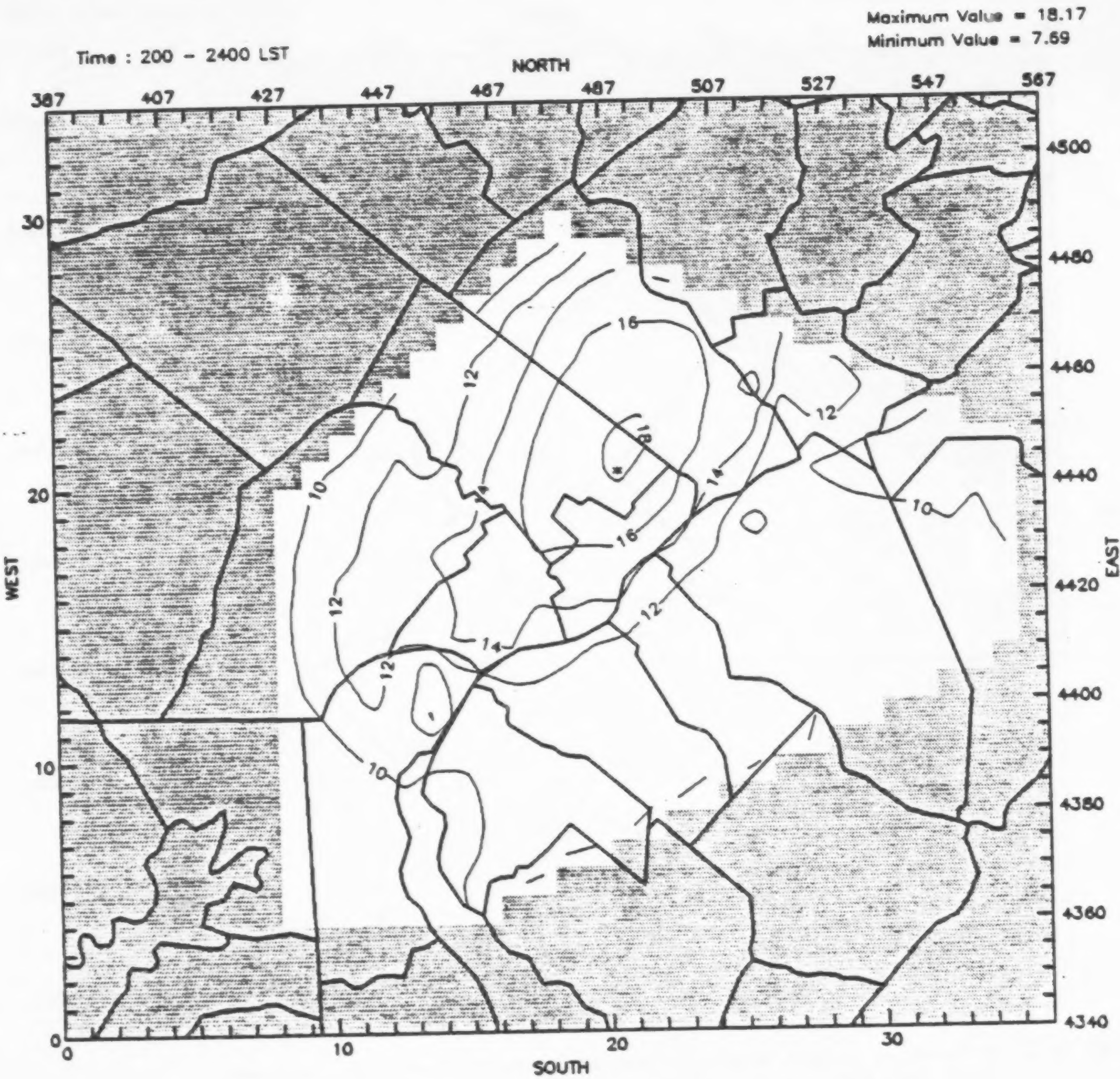
There is a slight reduction in the peak ozone concentration (1 percent) when CNG fueled vehicles are used in Philadlephia (Table 3-3 and Figure 3-33). Daily maximum ozone concentrations for the 1995 CNG emission scenario decrease by as much as 0.5 pphm when compared to the 1995 new regulations for gas vehicles emission scenario (Figure 3-34). Due to the large influence of transport and other nonmobile emission sources in the Philadelphia region the alternative fuels do not have as big of an effect on urban ozone concentrations as seen in Dallas-Fort Worth and St. Louis.

Discussion

The calculation of the effects of alternative fuels on urban ozone concentrations in 1995 is highly dependent on the mix of the emissions inventories. Current emission control policy is focusing on reducing VOC emissions from the transportation sector. Thus it is projected that by 1995 there will be a substantial reduction in mobile source VOC emissions. However due to growth in the region current emission projection factors estimate that VOC emissions from other nonmobile sources will increase. The net result is that it is estimated that the influence of mobile source emissions will be substantially lower than it is currently. For example, as seen in Table 2-1, it is estimated that the contribution of mobile sources to the total anthropogenic VOC emission inventory in Dallas-Fort Worth will almost be halved when comparing the 1985 (64 percent) to the 1995 (38 percent) base case inventories.

The results on alternative fuels presented here raise several important issues:

1. Are current future year mobile source emission reduction estimates overly optimistic in the amount of emission reductions;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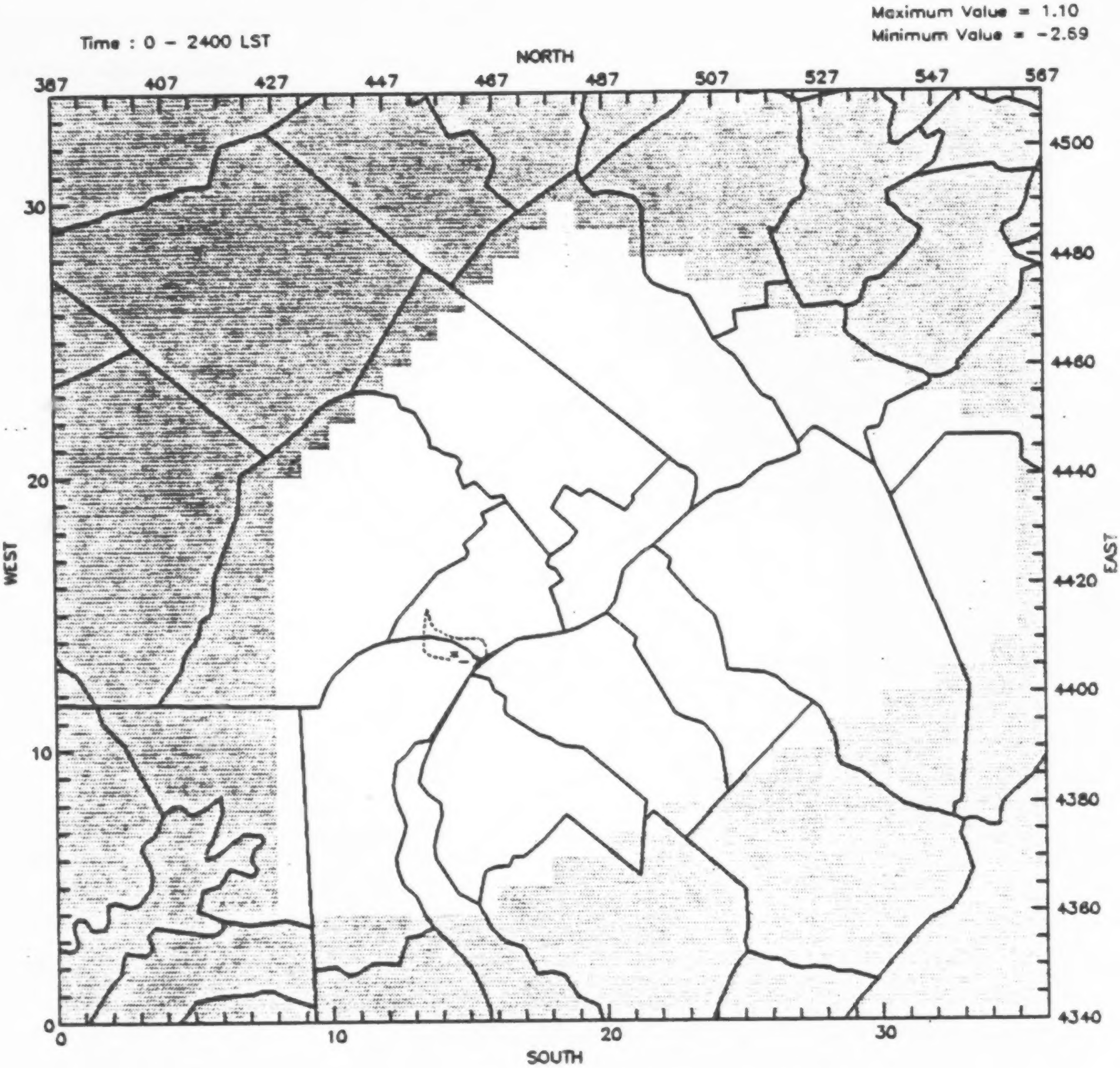
NORTH
387
407
427
447
467
487
507
527
547
567
4500
4480
4460
4440
4420
4400
4380
4360
4340
EAST
30
20
10
0
WEST
0
10
20
30
SOUTH
16
18
16
14
12
10
12
14
10
12
14
12
10
12
10

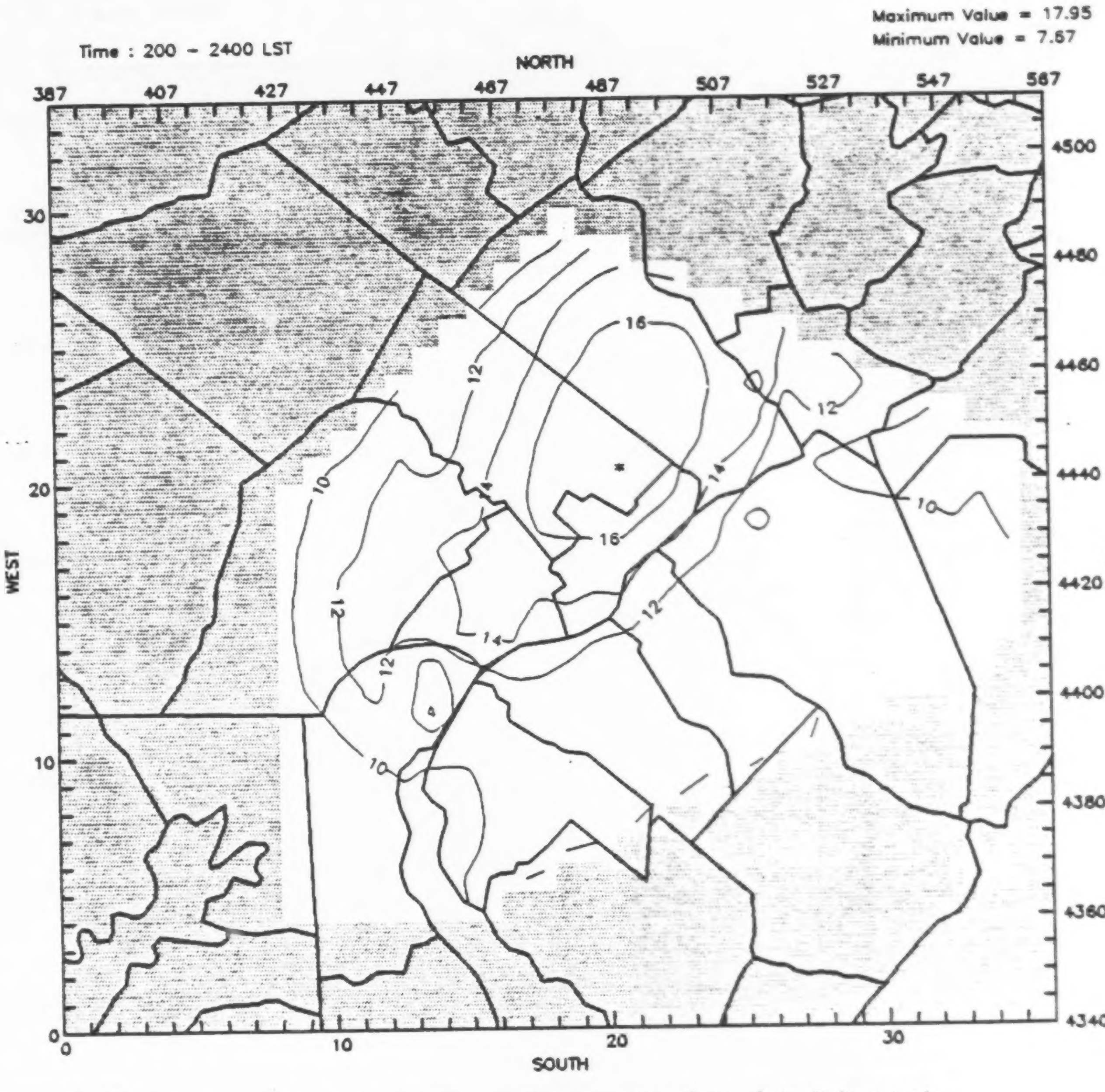
FIGURE 3-31. Predicted Daily Maximum Ozone Concentration (pphm) in Philadelphia on 13 July 1979 for 1995 M100 Emission Scenario

78



Maximum Value = 1.10
Minimum Value = -2.69
Time : 0 - 2400 LST
NORTH
387
407
427
447
467
487
507
527
547
567
4500
4480
4460
4440
4420
4400
4380
4360
4340
EAST
30
20
10
0
WEST
0
10
20
30
SOUTH

FIGURE 3-32. Differences in Daily Maximum Ozone Concentrations (ppb) between 1995 New Reg Gas and 1995 M100 emission scenarios (M100 - new reg gas) in Philadelphia on 13 July 1979.


Maximum Value = 17.95
Minimum Value = 7.67
Time : 200 - 2400 LST
NORTH
387
407
427
447
467
487
507
527
547
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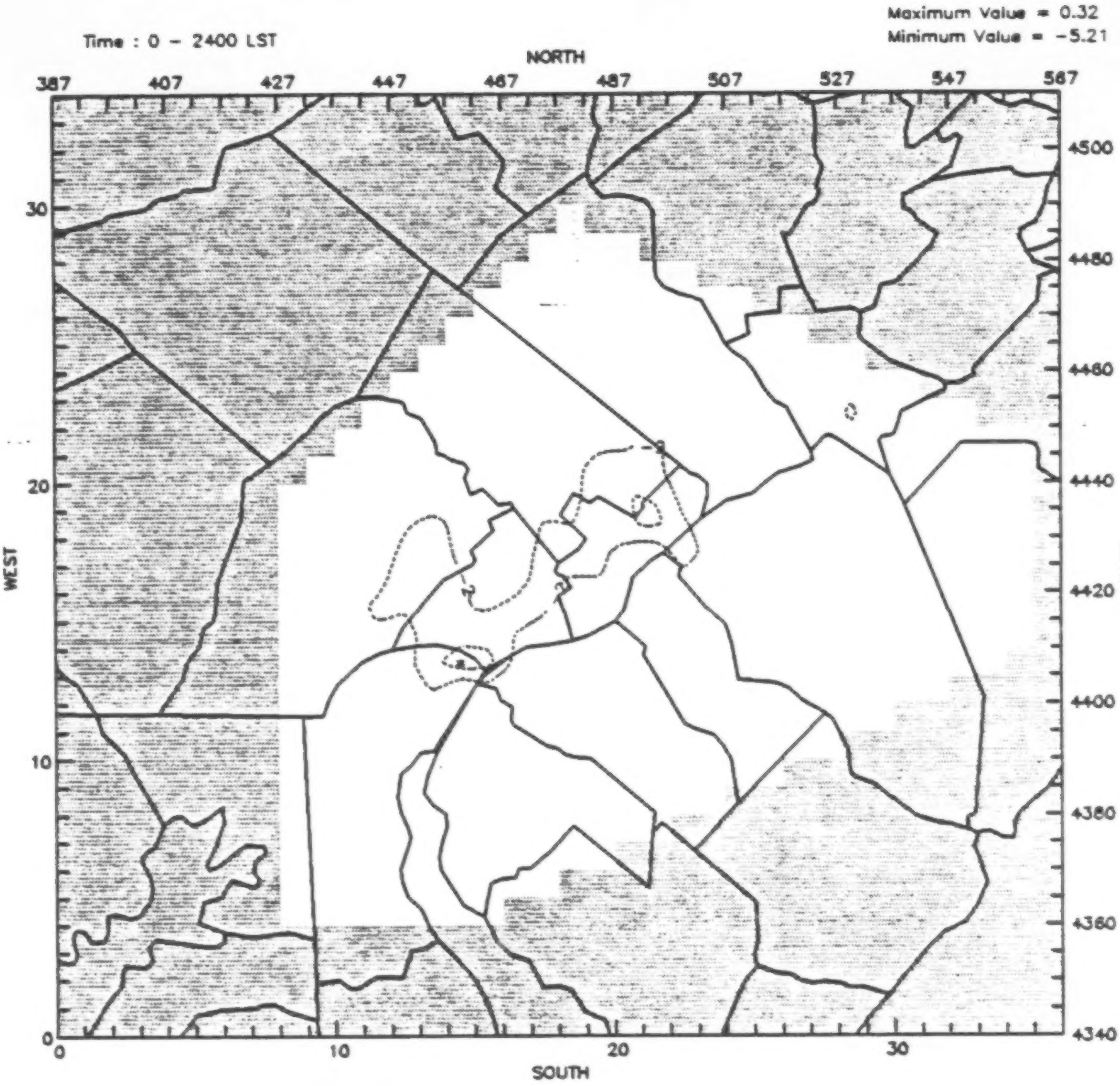
4500
4480
4460
4440
4420
4400
4380
4360
4340
EAST
30
20
10
0
WEST
0
10
20
30
SOUTH
16
16
14
14
12
12
12
12
10
10
10

FIGURE 3-33. Predicted Daily Maximum Ozone Concentration (pphm) in Philadelphia on 13 July 1979 for 1995 CNG Emission Scenario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407
427
447
467
487
507
527
547
567
WEST
30
20
10
0
EAST
4500
4480
4460
4440
4420
4400
4380
4360
4340
SOUTH
0
10
20
30

FIGURE 3-34. Differences in Daily Maximum Ozone Concentrations (ppb) between 1995 New Reg Gas and 1995 CNG emission scenarios (cng - new reg gas) in Philadelphia on 13 July 1979.

2. Are the emission projections for the other source categories over- or underestimates of actual values; and

3. Given that the current emission projections are correct, then the ozone attainment policy needs to consider reductions in VOC (and possibly NO_x . for some regions) emissions from sources outside the mobile sector.

4 RESULTS FOR THE EKMA MODELING

One of the initial goals of the EPA Five Cities UAM Study was to compare VOC emission control reductions needed to reach attainment of the ozone NAAQS calculated by the Empirical Kinetics Modeling Approach (EKMA) and the UAM. However, because of fundamental differences in model formulation and how the EKMA and UAM are used, this comparison is not possible. Given an observed VOC-to-NO_x ratio, an observed peak ozone concentration, and a spatially averged emission inventory the EKMA calculates the percentage of VOC emissions that needs to be reduced to reach attainment of the ozone NAAQS for a historical ozone episode (i.e. "design day"). Procedues for using the UAM usually involve a comprehensive model performance evaluation followed by the evaluation of how future year emission control strategies will effect urban ozone concentrations.

In this section we discuss the application of the EKMA to five cities: Dallas, Atlanta, Philadelphia, St. Louis, and New York. The EKMA analysis was performed by EPA/OAQPS using best estimates of model input data. The EKMA modeling was performed for the "design day" from 1983 to 1985, except for New York where a day with a slightly lower ozone concentration was used. Much of the EKMA modeling inputs were "generic" in nature, i.e. modeling inputs were based on analysis of observed data from the city in question rather then representing conditions for a given episode. The source of the key EKMA inputs are listed as follows:

EKMA INPUT	SOURCE
Emissions	1985 NAPAP Emission Inventory (Zimmerman et al., 1989)
Day	Design day from 1983 to 1985
Ozone aloft	From AIRS data base
Initial NMOC and NO_x	Based on measurments using data from 1984 to 1986 (Bauges, 1986)
Initial CO	Based on guidance for running EKMA
NMOC/NO_x ratio	From 1984 to 1986 measurement studies (Bauges, 1986)

Hourly temperatures	Local climatological summaries
Relative humidity	Local climatoligical summaries

The EKMA calculations were first performed in the CALC mode to make sure that the predicted peak ozone concentrations was within 30 percent of the design value. The model was then exercised in the EKMA mode to calculate the amount of VOC emissions reductions needed to reduce the design value to the ozone NAAQS. Note that NO_x emission reductions and biogenic emissions were not included in the analysis.

Table 4-1 lists the VOC emission reduction amounts required to reach attainment of the ozone NAAQS for the five cities as calculated by EKMA. As noted previously, it is impossible to compare these results with those produced by the UAM due to differences in the days studied, differences in the base emission inventories (1995 for UAM and 1985 for EKMA), lack of including biogenic emissions in the EKMA analysis, and inherent differences in model formulations and procedures for using the two models.

TABLE 4-1. Results of the EKMA modeling for five cities. (Biogenic emissions were not included in these analysis.)

City	Date Modeled	Percent VOC Emission Reductions Needed to Reach Attainment of the Ozone NAAQS
Dallas	27 June 1981	52
Atlanta	14 July 1983	55
Philadelphia	13 August 1985	25
St. Louis	26 August 1983	65
New York	13 June 1984	68

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Appendix A

MEMORANDUM OF 18 SEPTEMBER 1989 FROM EPA/OMS TO EPA/OPPE DESCRIBING PROCEDURES TO BE USED FOR DEVELOPING THE 1995 NEW REGULATION GAS VEHICLE, 1995 100 PERCENT METHANOL (M100) VEHICLE, AND 1995 100 PERCENT COMPRESSED NATURAL GAS (CNG) VEHICLE SCENARIOS

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
ANN ARBOR, MICHIGAN 48105

SEP 18 [illegible]

OFFICE OF
AIR AND RADIATION

MEMORANDUM

SUBJECT: Emission Factors for SAI Runs with CNG and Neat Methanol

FROM: Phil Lorang, Chief
Technical Support Staff

TO: Gene Durman, Chief
Air Economics Branch (PM-221)

THRU: Charles L. Gray, Jr., Director
Emission Control Technology Division

Recently, John Chamberlin, Robin Miles-McLean, and Dwight Atkinson called to ask for emission factor input for some SAI runs you are planning for Dallas, Philadelphia, and St. Louis using CNG and neat methanol vehicles (which would be LDVs and LDTs under the President's proposal).

We understand that the 1985 NAPAP inventory and source category growth factors to 1995 provided by Pechan are being used. For motor vehicle emissions excluding refueling, SAI in effect recovers 1985 VMT by dividing the 1985 tons by a 1985 emission factor. SAI then multiplies the VMT by the Pechan growth factor and the scenario-specific 1995 emission factor to obtain the 1995 motor vehicle tons. The vehicle categories are LDGV, LDGT, HDGV, and "HDD" (which in Pechan's treatment is really the aggregate of LDDV, LDDT, and HDDV), and tons and VMT are distinct for three road types in each county. Emission factors are for the day as a whole, not hour-by-hour.

As you and the other involved EPA staff know, the 1985 NAPAP inventory has a speed problem, towards overestimating average speed and underestimating exhaust emissions. I recommend we assume that all VMT in 1995 occurs at 20 mph. (The 1985 emission factors used to recover 1985 VMT should continue to be based on the speeds assumed for the 1985 NAPAP inventory.) This simple treatment does not interfere with the gasoline versus methanol versus CNG comparison. It does mean that none of these three cases should be compared to any previous run based on the stock NAPAP inventory approach.

With this speed assumption, providing the required motor vehicle inputs is fairly easy, given the head start from our work with OAQPS and Pechan. Gasoline emission factors have been prepared for each of the three cities, with the minimum and maximum temperatures and the gasoline RVP for each city used as input. For each city, separate tables have been prepared for gasoline-fueled light-duty vehicles and light-duty trucks. SAI provided us with the minimum and maximum temperatures for Dallas, Philadelphia, and St. Louis as inputs.

Tables 1 through 6 give LDGV and LDGT emission factors for the gasoline cases. For both LDV and LDT the standards proposed by the President for his Clean Air Act revisions sent to Congress are assumed. MOBILE4 was run out to steady state using these standards and the temperature ranges SAI provided as input. An RVP of 9.0 psi is assumed for all three cities; data for a 7.8 psi RVP fuel are also given in Philadelphia and St. Louis since the lower RVP fuels may be used there.

The evaporative and running loss emissions have been "corrected" to account for improvements in the test procedure that would reduce excess evaporative emissions. This involved a comparison of the standard MOBILE4 output (called A) with an output eliminating tampering and fuel switching (called B) and a rough estimate (0.11 g/mile, called C) of what evaporative emissions would be under the best system. The percent reduction to apply to the standard MOBILE4 output (A) to get the final evaporative and running loss estimates given in the tables were obtained by the following formulas:

Evaporative % reduction = 70% (B-C)/A
Running loss % reduction = 80% (B/A)

The hydrocarbon speciation for the gasoline cases should be as given in my previous memos and notes, which are attached and referenced in the tables.

The emission factors for the vehicles optimized for 100% methanol (Tables 7 and 8) were taken from the latest version of the draft special report, at one time titled "Clean, Alternative Fuels - The President's Proposal." For evaporative and running loss emissions, the emission factors in the special report are taken directly, and not adjusted for temperature. Evaporative and running loss emissions from M100 vehicles are expected to be very insensitive to local temperatures because of the relatively high boiling point of M100. To estimate the NMHC, methanol, and formaldehyde emission factors for M100 trucks, the M100 vehicle emission factors were adjusted by applying the ratios of LDT to LDV hydrocarbon emission factors obtained in the special MOBILE4 run. This accounts for presumably higher exhaust standards, larger fuel tank volumes, and lesser heating of the fuel tank.

The hydrocarbon speciation for the M100 vehicles and trucks (excluding methanol and formaldehyde which are explicit in Tables 7 and 8) should be that given in the attached report prepared by the California Air Resources Board titled, "Definition of a Low-Emission Motor Vehicle in Compliance with the Mandates of Health and Safety Code Section 39037.05 (Assembly Bill 234, Leonard, 1987)." However, you should probably assume that the reported number for butane is about 50% butane and 50% butadiene. EPA ORD has some preliminary detailed speciation data for a methanol fueled vehicle; ORD personnel (Peter Gabele) indicate that these data are consistent with the California results.

The NMHC emission factors for the CNG vehicles are based on test data discussed in the attached 1989 paper titled, "Motor Vehicle Emission Characteristics and Air Quality Impacts of Methanol and Compressed Natural Gas" by Jeff Alson, Jon Adler, and Tom Baines. The NMHC emission factor is an average of those for the dedicated and dual-fueled vehicles. This approach was used as a way to try to account for in-use deterioration from an optimized CNG vehicle. We are assuming, as stated in the EPA Guidance Document, that there are no evaporative emissions (and thus no running loss or refueling losses) from CNG vehicles. The formaldehyde emission factor was calculated by applying the formaldehyde fraction found in the attached CARB report to the NMHC exhaust emission factor. The same procedure used for M100 was used to estimate emission factors for CNG trucks.

The NMHC speciation for the CNG vehicles and trucks should be as given in the CARB report. Total HC emissions for CNG vehicles consist of about 90% methane and 10% NMHC; you may need to include this methane fraction in your runs. By contrast, methane levels for gasoline vehicles are about 10% of the total hydrocarbon levels. The methane levels for the 100% methanol vehicles are about 50% of the total hydrocarbon levels.

CO emissions from the M100 CNG vehicles and trucks are assumed to be the same as the gasoline case. (With a 0.2 NOx standard and without a lower CO standard for CNG, we should not count on a CO reduction under summer conditions.) For NOx emissions, it is assumed that gasoline, M100, and CNG vehicles and trucks emit equal NOx. Even though available data show a tendency towards an increase in NOx for CNG, we are assuming that the CNG vehicles and trucks will be modified to meet the Administration Bill's NOx standards.

Emission factors for uncontrolled refueling emissions are given in the tables. For the gasoline case, you should assume 66% control (74% per station; 10,000 gallons/month exemptions). For the M100 case, you can incorporate some temperature dependence by assuming 24% as much methanol as there is NMHC in the controlled 9 psi gasoline case. This is about 91% control of the mass. For the CNG case, you should assume no refueling emissions.

We strongly recommend that SAI be required to account for reduction in VOC emissions from production, storage, and transfer of gasoline. Jim Wilson's letter on this subject would be the starting point. Inventory categories will have to be matched up. The M100:gasoline ratio from the refueling category could be used to adjust other transfer and storage categories. It will be important to be aware of whether the gasoline inventories already represent some control or not.

You should assume that LDDV, LDDT, HDGV, and HDDV emissions are the same in all scenarios. None is affected by the Administration bill, so standard MOBILE4 applies. SAI and Pechan should coordinate on the treatment of diesel vehicles. Diesel vehicles are not sensitive to temperature so all three cities will use the same emission factors.

I hope this information is helpful to you. If you or the SAI personnel have further questions, please call either Joe Somers (FTS 374-8321, commercial 313-668-4321) or me (FTS 374-8374, commercial 313-668-4374).

Attachments

cc: Richard D. Scheffe
Ken Knapp

Table 1

Projected In-Use Emissions For
Light-Duty Gasoline Vehicles (grams per mile)
Dallas (T min. 77°, T max. 102°)

Type of Emission	7.8 psi RVP			9.0 psi RVP		
	NMHC	CO	NOx	NMHC	CO	NOx
Exhaust	0.45	5.56	0.71	0.50	7.36	0.73
Evap	0.184			0.26		
Running Losses	0.154			0.39		
Uncontrolled Refueling	0.17			0.20		

Gasoline NMHC speciation guidance provided in the August 23, August 30, and September 2, 1988 memos from Phil Lorang to Ralph Morris, and a September 7, 1988 memo from Phil Lorang to Gene Durman.

Exhaust emission factors calculated at an average speed of 20 mph.

66% control of these refueling emissions should be assumed.

Table 2

Projected In-Use Emissions For
Light-Duty Gasoline Vehicles (grams per mile)
Philadelphia (T min. 72°, T max. 92°)

Type of Emission	9.0 psi RVP NMHC	CO	NOx
Exhaust	0.53	7.90	0.72
Evap	0.187		
Running Losses	0.136		
Uncontrolled Refueling	0.20		

Gasoline NMHC speciation guidance provided in the August 23, August 30, and September 13, 1988 memos from Phil Lorang to Ralph Morris, and a September 7, 1988 memo from Phil Lorang to Gene Durman.

Exhaust emission factors calculated at an average speed of 20 mph.

66% control of these refueling emissions should be assumed.

Table 3

Projected In-Use Emissions For Light-Duty
Gasoline Vehicles (grams per mile)
St. Louis (T min. 68°, T max. 92°)

Type of Emission	7.8 psi RVP			9.0 psi RVP		
	NMHC	CO	NOx	NMHC	CO	NOx
Exhaust	0.52	7.78	0.72	0.52	7.78	0.72
Evap	0.163			0.183		
Running Losses	0.086			0.142		
Uncontrolled Refueling	0.17			0.20		

Gasoline NMHC speciation guidance provided in the August 23, August 30, and September 2, 1988 memos from Phil Lorang to Ralph Morris, and a September 7, 1988 memo from Phil Lorang to Gene Durman.

Exhaust emission factors calculated at an average speed of 20 mph.

66% control of these refueling emissions should be assumed.

Table 4

Projected In-Use Emissions For Light-Duty Gasoline Trucks (grams per mile) Dallas (T min. 77°, T max. 102°)

Type of Emission	7.8 psi RVP			9.0 psi RVP		
	NMHC	CO	NOx	NMHC	CO	NOx
Exhaust	0.53	4.89	1.11	0.63	6.68	1.13
Evap	0.211			0.278		
Running Losses	0.142			0.322		
Uncontrolled Refueling	0.23			0.26		

Gasoline NMHC speciation guidance provided in the August 23, August 30, and September 2, 1988 memos from Phil Lorang to Ralph Morris, and a September 7, 1988 memo from Phil Lorang to Gene Durman.

Exhaust emission factors calculated at an average speed of 20 mph.

66% control of these refueling emissions should be assumed.

Table 5

Projected In-Use Emissions For Light-Duty Gasoline Trucks (grams per mile) (Philadelphia (T min. 72°, T max. 102°)

Type of Emission	9.0 psi RVP		
	NMHC	CO	NOx
Exhaust	0.64	7.84	1.12
Evap	0.201		
Running Losses	0.136		
Uncontrolled Refueling	0.26		

Gasoline NMHC speciation guidance provided in the August 23, August 30, and September 2, 1988 memos from Phil Lorang to Ralph Morris, and a September 7, 1988 memo from Phil Lorang to Gene Durman.

Exhaust emission factors calculated at an average speed of 20 mph.

66% control of these refueling emissions should be assumed.

Table 6

Projected In-Use Emissions For Light-Duty Gasoline Trucks (grams per mile)
St Louis (T min. 68°, T max. 92°)

Type of Emission	7.8 psi RVP			9.0 psi RVP		
	NMHC	CO	NOx	NMHC	CO	NOx
Exhaust	0.64	7.13	1.12	0.64	7.13	1.12
Evap	0.173			0.214		
Running Loss	0.082			0.134		
Uncontrolled refueling	0.23			0.26		

Gasoline NMHC speciation guidance provided in the August 23, August 30, and September 2, 1988 memos from Phil Lorang to Ralph Morris, and a September 7, 1988 memo from Phil Lorang to Gene Durman.

Exhaust emission factors calculated at an average speed of 20 mph.

66% control of these refueling emissions should be assumed.

Projected In-Use Emissions for Light-Duty Alternative-Fueled Vehicles

(grams per mile)

Type of Emission	Vehicles Optimized for 100% Methanol					Dedicated CNG Vehicles				
	NMHC	MeOH	HCHO	CO	NOx	NMHC	MeOH	HCHO	CO	NOx
Exhaust	0.049	0.490	0.015	Same as LDGV	Same as LDGV	0.186	0	0.004	Same as LDGV	Same as LDGV
Hot Soak/ Diurnal	0	0.020	0	0	0	0	0	0	0	0
Running Loss	0	0.007	0	0	0	0	0	0	0	0
Refueling	0	See Note #3	0	0	0	0	0	0	0	0

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1. Speciation for M100 and CNG exhaust NMHC should be taken from the May 19, 1989 CARB technical report titled, "Definition of a Low-Emission Motor Vehicle in Compliance with the Mandates of Health and Safety Code Section 39037.05 (Assembly Bill 234, Leonard, 1987)."

2. Exhaust emission factors calculated at an average speed of 20 mph.

3. For the M100 case, assume 24% as much methanol as there is NMHC in the gasoline case. This is 91% control of the mass.

Table 8

Projected In-Use Organic Emissions for Light-Duty Alternative-Fueled Trucks

(grams per mile)

Type of Emission	Trucks Optimized for 100% Methanol					Dedicated CNG Trucks				
	NMHC	MeOH	HCHO	CO	NOx	NMHC	MeOH	HCHO	CO	NOx
Exhaust	0.057	0.578	0.018	Same as LDGT	Same as LDGT	0.220	0	0.006	Same as LDGT	Same as LDGT
Hot Soak/ Diurnal	0	0.032	0	0	0	0	0	0		0
Running Loss	0	0.017	0	0	0	0	0	0	0	0
Refueling	0	See Note #3	0	0	0	0	0	0	0	0

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1. Speciation for M100 and CNG exhaust NMHC should be taken from the May 19, 1989 CARB technical report titled, "Definition of a Low-Emission Motor Vehicle in Compliance with the Mandates of Health and Safety Code Section 39037.05 (Assembly Bill 234, Leonard, 1987)."

2. Exhaust emission factors calculated at an average speed of 20 mph.

3. For the M100 case, assume 24% as much methanol as there is NMHC in the gasoline case. This is 91% control of the mass.